9 Light-Reflection and Refraction

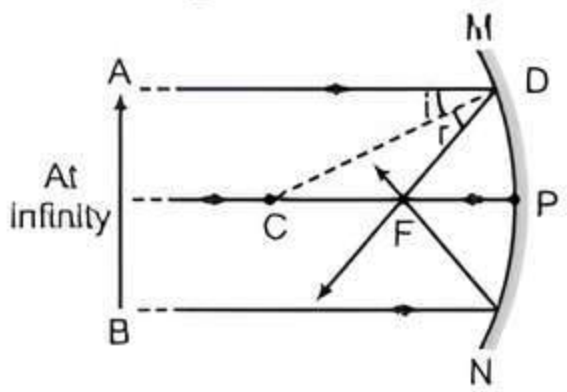
Fastrack Revision

- **Reflection of Light:** The process of bouncing back of the light rays which fall on the polished surface of an object is called reflection of light.
- **Laws of Reflection:** The laws of reflection of light are:
  (i) The angle of reflection is equal to the angle of incidence *i.e.*, $\angle r = \angle i$.
  (ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.
- **Object:** Anything which gives out light rays is called an object *e.g.*, a bulb, a candle etc.
- **Images:** The point at which the reflected rays converge or the point from where the reflected rays appear to diverge is known as 'Image'. Images are of two types–real image and virtual image. The image which can be obtained on a screen is called real image while the image which cannot be obtained on a screen is called a virtual image.
- **Mirror:** The mirror is a shiny polished surface which can reflect the rays of light. Mirrors can be plane (reflecting surface is plane) or spherical (reflecting surface is a part of hollow sphere). Spherical mirrors can be of two types:
  (i) Concave mirror (reflecting surface is curved inwards) and
  (ii) Convex mirror (reflecting surface is curved outwards).
- **Characteristics of Image Formed by a Plane Mirror:** Image formed by a plane mirror is:
  (i) virtual and erect.
  (ii) laterally inverted.
  (iii) of the same size as the object.
  (iv) as far behind the mirror as the object is in front of it.
- **Special Rays for Formation of Image:** The intersection of at least two reflected rays gives the position of image of the point object. Any two of the following rays can be considered for locating the image.
  (i) A ray parallel to the principal axis, after reflection, will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.
  (ii) A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror, after reflection, will emerge parallel to the principal axis.
  (iii) A ray passing through the centre of curvature of a concave mirror or directed in the direction of the centre of curvature of a convex mirror, after reflection, is reflected back along the same path.
  (iv) A ray incident obliquely to the principal axis, towards the pole of the mirror, on the concave mirror or a convex mirror is reflected obliquely.

Formation of Image by Concave Mirror for Different Positions of the Object:

S. No.	Position of Object	Position of Image	Nature and Size of Image
1.	Object at infinity [see fig. (a)]	Image is formed at the focus or in the focal plane	Real, inverted, extremely diminished in size
2.	Object beyond the centre of curvature but at a finite distance [see fig. (b)]	Image is formed between the focus and the centre of curvature	Real, inverted and diminished
3.	Object at the centre of curvature [see fig. (c)]	Image is formed at the centre of curvature	Real, inverted and of the same size as that of object
4.	Object between the focus and the centre of curvature [see fig. (d)]	Image is formed beyond the centre of curvature	Real, inverted and larger than object
5.	Object at the focus [see fig. (e)]	Image is formed at infinity	Real, inverted and extremely magnified
6.	Object between the pole and the focus [see fig. (f)]	Image is formed behind the mirror	Virtual, erect and magnified

Ray Diagrams for the Image Formation by a Concave Mirror:



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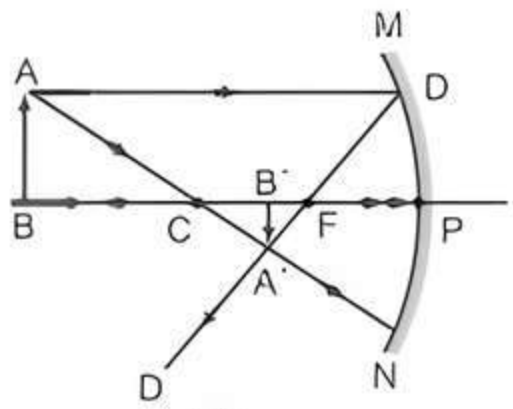

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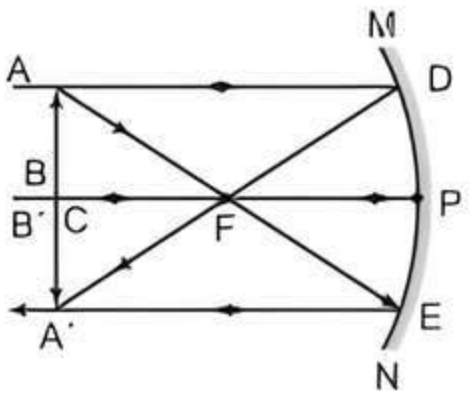

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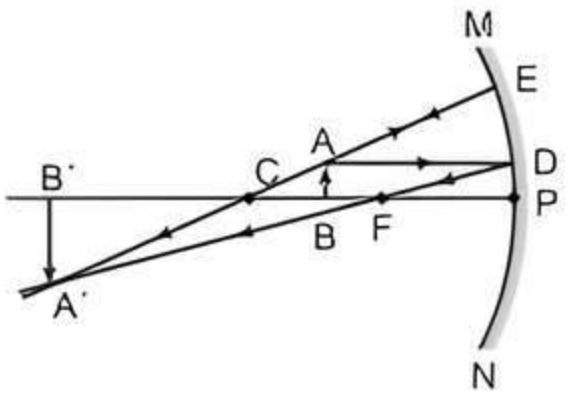

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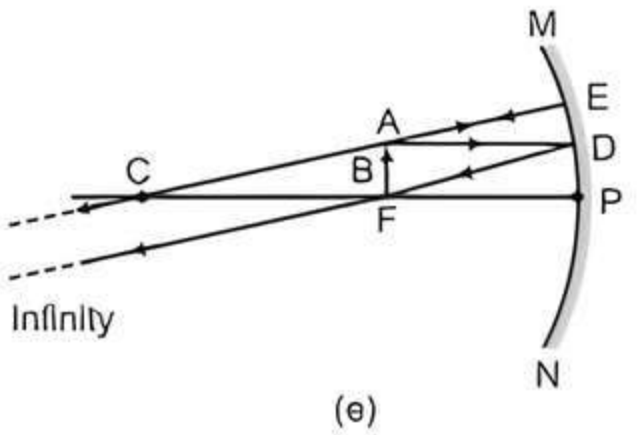

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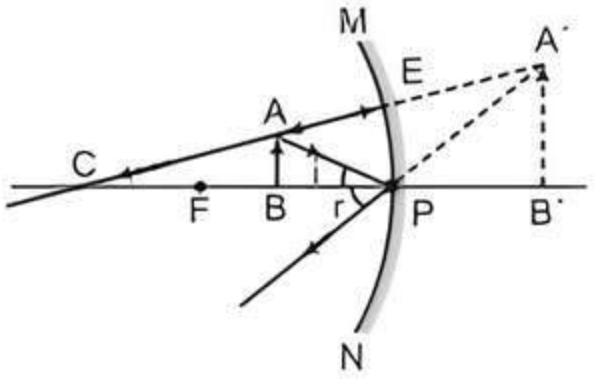
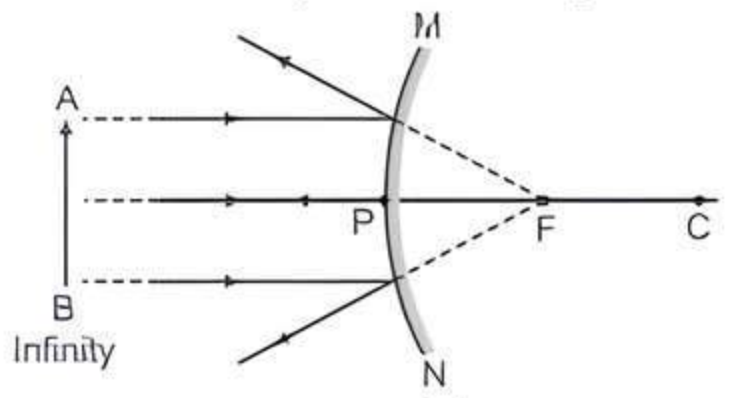


(f)

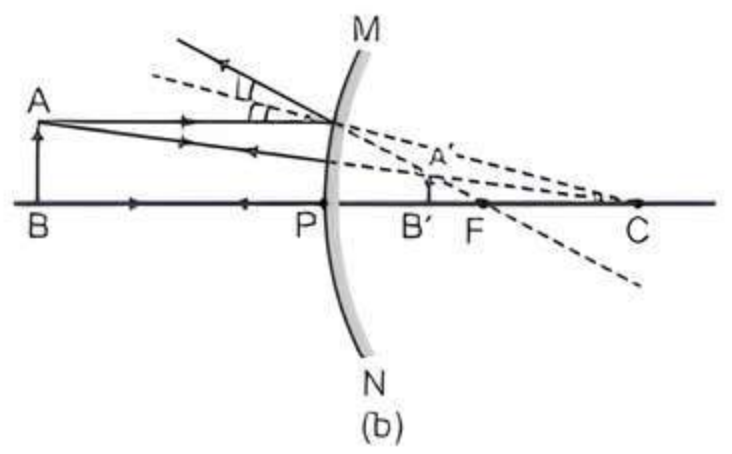
Formation of Image by Convex Mirror for Different Positions of the Object:

S. No.	Position of Object	Position of Image	Nature and Size of Image
1.	Object at infinity [see fig. (a)]	Image is formed at the principal focus, behind the mirror	Virtual, erect and extremely diminished
2.	Object between infinity and the pole (*i.e.*, at a finite distance) [see fig. (b)]	Image is formed between the principal focus and the pole, behind the mirror	Virtual, erect and diminished

Ray diagrams for the image formation by a convex mirror:



(a)



(b)

- **Uses of Concave Mirrors:**
  - (i) Used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.
  - (ii) Used as shaving mirrors to see a larger image of the face.
  - (iii) Used by dentists to see large images of the teeth of patients.
  - (iv) Used to concentrate sunlight to produce heat in solar furnaces.

- **Use of Convex Mirrors:** Used as rear-view (wing) mirrors in vehicles because they always give an erect and diminished image. Also, they have a wider field of view as they are curved outwards.
- **Mirror Formula:** It is a relation between distance of object, distance of image from the pole of the mirror and its focal length *i.e.*, relation between 'u', 'v' and 'f' is given by

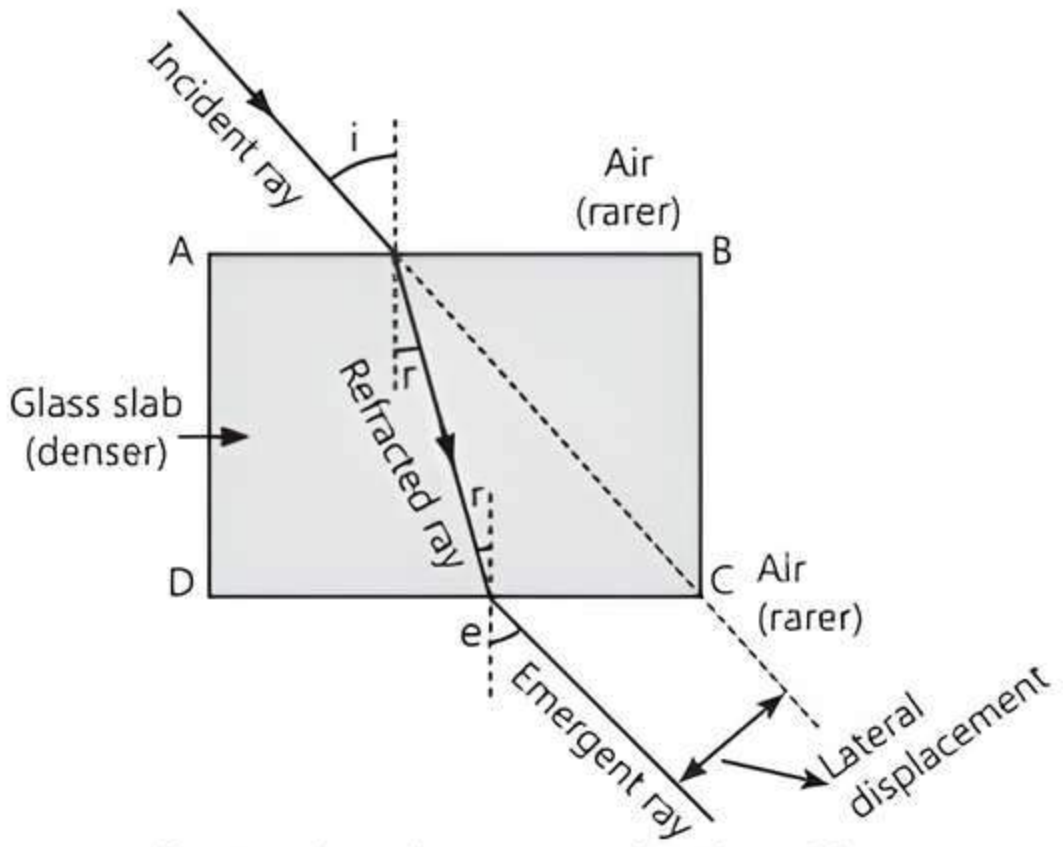
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

- **Magnification or Linear Magnification:** It is defined as the ratio of height of image to the height of the object. It is represented by 'm'. It is also related to the distance of object (u) and distance of image (v) *i.e.*,

$$\text{Magnification } (m) = \frac{\text{Height of image } (h_i)}{\text{Height of object } (h_o)}$$

$$= -\frac{\text{Image distance}}{\text{Object distance}} = \frac{-v}{u}$$

- **Refraction:** Bending of light ray when it passes from one medium to another is called refraction. When light travels from a rarer medium to a denser medium, it bends towards the normal ($i > r$) and when it travels from a denser medium to a rarer medium, it bends away from the normal ($i < r$), where, i = Angle of incidence, r = Angle of refraction.
- **Refraction through a Rectangular Glass Slab:** When a light ray is obliquely incident on a glass slab, then the emergent ray is parallel to the direction of incident ray, but it is shifted slightly sidewards. Here, refraction takes place twice, first, when the ray enters the glass slab from air and second, when it exits from the glass slab to air. Both the cases of refraction have been shown in the given figure. The extent of bending of the ray of light at opposite parallel faces AB and CD of rectangular glass slab is equal and opposite. Hence, the ray emerging from face CD becomes parallel to the incident ray, but shifts slightly sidewards.



Refraction through a Rectangular Glass Slab

Here, i = Angle of incidence,
r = Angle of refraction,
e = Angle of emergence.

- **Laws of Refraction:** Refraction of light occurs according to the following laws:
  - (i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.
  - (ii) The ratio of sine of angle of incidence to the sine of angle of refraction for light of a given colour is constant for a given pair of media (Snell's law). It is expressed as,

$$\frac{\sin i}{\sin r} = \text{Constant } (\mu \text{ or } \eta)$$

This constant is known as refractive index (μ). It can also be expressed as:

$$\mu \text{ or } \eta = \frac{\text{Speed of light in vacuum or air}}{\text{Speed of light in medium}}$$

- **Lens:** The transparent refracting medium bounded by two surfaces in which at least one surface is curved, is called lens. Lenses are of two types:
  - (I) **Convex lens** is thicker at the centre and thinner at the edges.
  - (II) **Concave lens** is thinner at the centre and thicker at the edges.

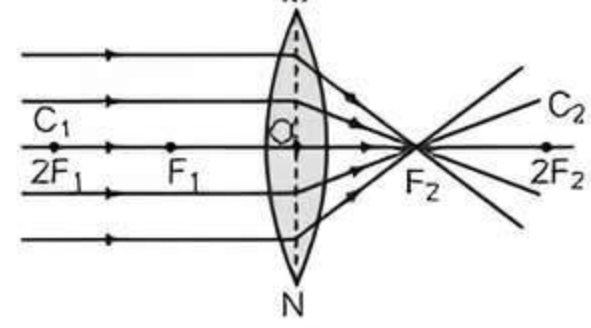
Concave lens is a diverging lens (diverges the light) and convex lens is a converging lens (converges the light).

- **Special Rays for Formation of Image:** For drawing ray diagrams in lenses, alike of spherical mirrors, we consider any two of the following rays:
  - (i) A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of the lens. In case of a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens.
  - (ii) A ray of light passing through a principal focus, after refraction from a convex lens, will emerge parallel to the principal axis. A ray of light appearing to meet at the principal focus of a concave lens, after refraction, will emerge parallel to the principal axis.
  - (iii) A ray of light passing through the optical centre of a lens will emerge without any deviation.

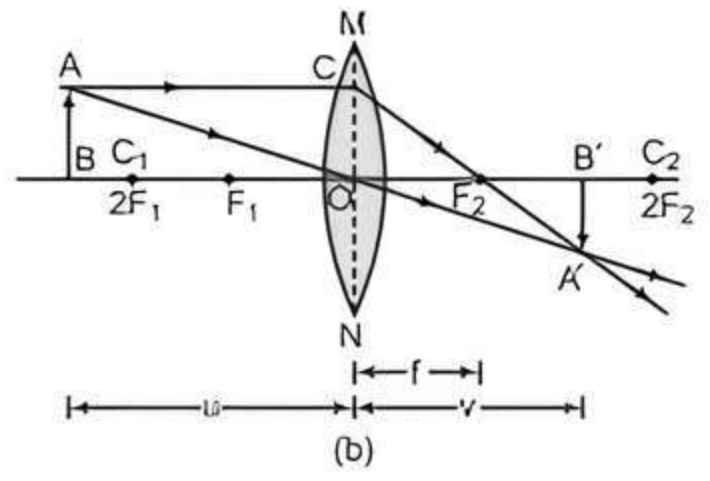
Formation of Image by Convex Lens for Different Positions of the Object:

S. No.	Position of Object	Position of Image	Size of Image	Nature of Image
1.	Object at infinity [see fig. (a)]	Image is formed at F_2	Extremely diminished	Real and inverted
2.	Object beyond $2F_1$ (at a finite distance) [see fig. (b)]	Image is formed between F_2 and $2F_2$	Diminished	Real and inverted
3.	Object at $2F_1$ [see fig. (c)]	Image is formed at $2F_2$	Same size	Real and inverted
4.	Object between F_1 and $2F_1$ [see fig. (d)]	Image is formed beyond $2F_2$	Magnified	Real and inverted
5.	Object at F_1 [see fig. (e)]	Image is formed at infinity	Highly magnified	Real and inverted
6.	Object between lens and F_1 [see fig. (f)]	Image is formed on the same side of the lens as the object	Magnified	Virtual and erect

- **Ray Diagrams for the Image Formation by a Convex Lens:**



(a)



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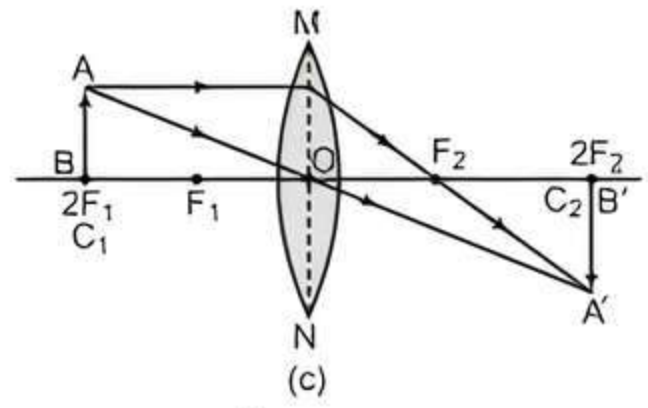

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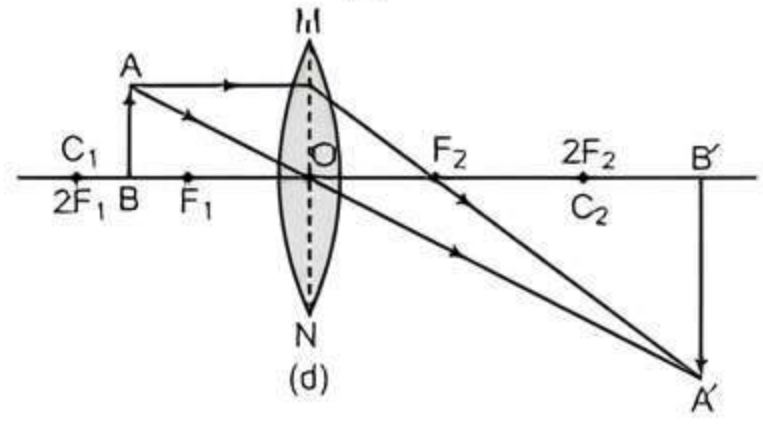

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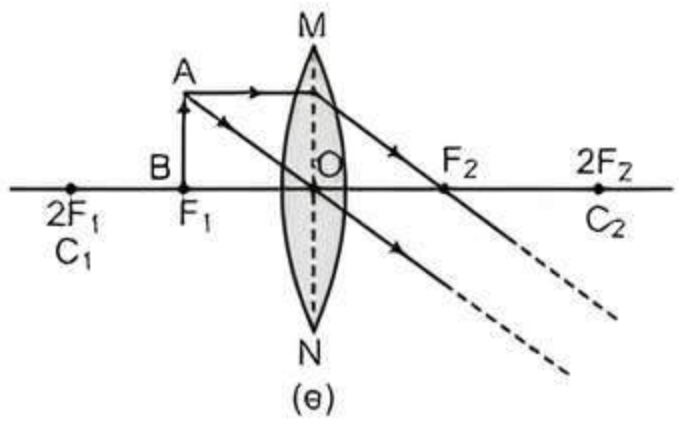

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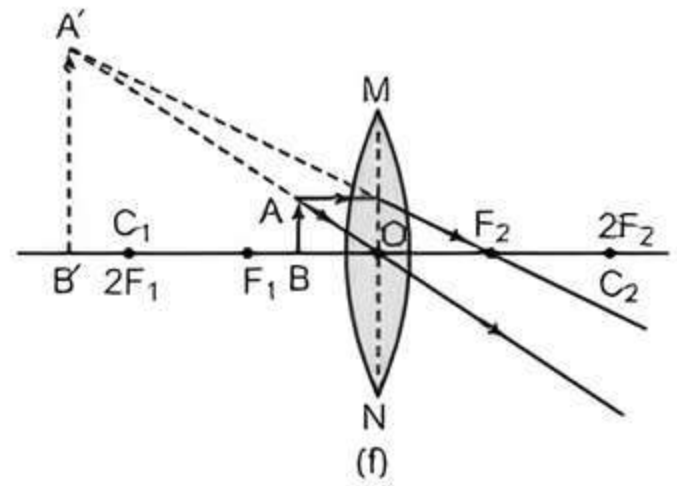
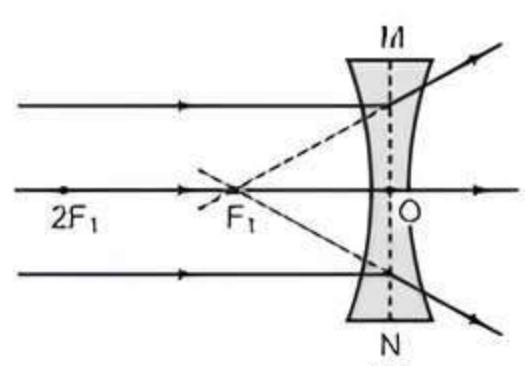


(f)

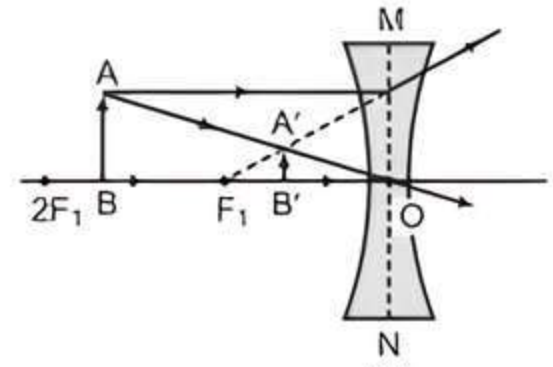
▶ **Formation of Image by Concave Lens for Different Positions of the Object:**

S.No.	Position of Object	Position of Image	Size of Image	Nature of Image
1.	Object at infinity [see fig. (a)]	Image is formed at the focus on the same side of lens as the object	Highly diminished	Virtual and erect
2.	Object anywhere between optical centre and infinity [see fig. (b)]	Image is formed between the focus and the optical centre and on the same side of lens as the object	Diminished	Virtual and erect

▶ **Ray diagrams for the Image Formation by a Concave Lens:**



(a)



(b)

▶ **Lens Formula:** It represents the relationship between the object distance (u), the image distance (v) and the focal length (f). It can be expressed as,

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

▶ **Linear Magnification:** The ratio of the height of image to the height of object is known as linear magnification (m).

$$\text{Linear magnification}\,(m)=\frac{h_i}{h_o}\ \text{or}\ \frac{v}{u}$$

▶ **Power of a Lens:** The ability of a lens to converge or diverge light rays after refraction is known as power (P) of the lens. It is always the reciprocal of focal length.

$$P=\frac{1}{f(\text{m})}=\frac{100}{f(\text{cm})}$$

(i) The unit of power of lens is dioptre (D).

(ii) One dioptre is the power of a lens whose focal length is 1 m and is represented by 'D '. Power of a convex lens is positive and that of a concave lens is negative.

Practice Exercise

Multiple Choice Questions

Q 1. The laws of reflection hold true for: *(CBSE 2020)*

a. plane mirrors only b. concave mirrors only
c. convex mirrors only d. all reflecting surfaces

Q 2. When an object is kept within the focus of a concave mirror, an enlarged image is formed behind the mirror. This image is: *(CBSE 2020)*

a. real b. inverted
c. virtual and inverted d. virtual and erect

Q 3. Three students A, B and C focussed a distant building on a screen with the help of a concave mirror. To determine focal length of the concave mirror they measured the distances as given below: *(CBSE 2017)*

Student A: From mirror to the screen

Student B: From building to the screen

Student C: From building to the mirror

Who measured the focal length correctly?

a. Only A b. Only B
c. A and B d. B and C

Q 4. In torches, search lights and headlights of vehicles, the bulb is placed: *(NCERT EXEMPLAR)*

a. between the pole and the focus of the reflector
b. very near to the focus of the reflector
c. between the focus and centre of curvature of the reflector
d. at the centre of curvature of the reflector

Q 5. An object is placed in front of a convex mirror. Its image is formed: *(CBSE SQP 2023-24)*

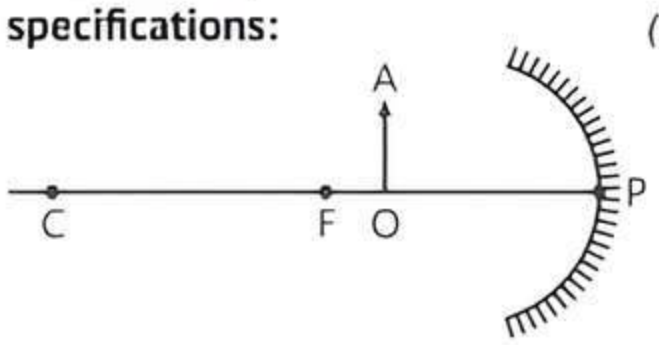
a. at a distance equal to the object distance in front of the mirror.
b. at twice the distance of the object in front of the mirror.
c. half the distance of the object in front of the mirror.
d. behind the mirror and it's position varies according to the object distance.

Q 6. An object is placed in front of a convex mirror at infinity. According to the New Cartesian Sign Convention, the sign of the focal length and the sign of the image distance in this case are respectively:

(CBSE 2023)

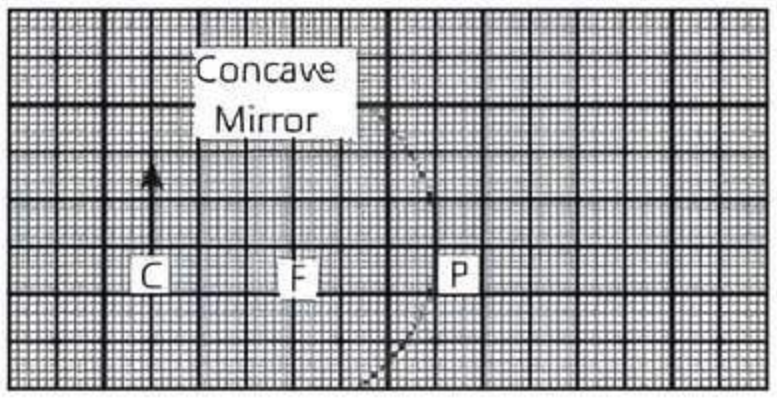
a. +, − b. −, +
c. −, − d. +, +

Q 7. For the diagram shown, according to the new Cartesian sign convention, the magnification of the image formed will have the following specifications: *(CBSE 2021 Term-1)*



a. Sign – Positive. Value – Less than 1
b. Sign – Positive. Value – More than 1
c. Sign – Negative. Value – Less than 1
d. sign – Negative. Value – More than 1

Q 8.



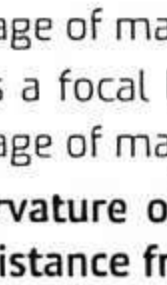
Examine the above figure and state which of the following option is correct? (one small box in the figure is equal to 1 cm) *(CBSE SQP 2021 Term-1)*

a. The mirror has a focal length of –6 cm and will produce an image of magnification +1.
b. The mirror has a focal length of –3 cm and will produce an image of magnification –1.
c. The mirror has a focal length of –3 cm and will produce an image of magnification +1.
d. The mirror has a focal length of –6 cm and will produce an image of magnification –1.

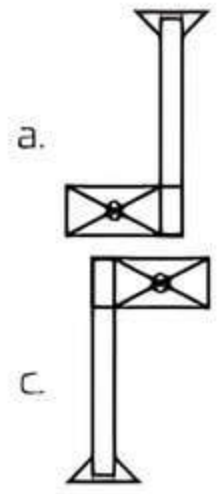
Q 9. The radius of curvature of a converging mirror is 30 cm. At what distance from the mirror should an object be placed so as to obtain a virtual image? *(CBSE 2021 Term-1)*

a. Infinity
b. 30 cm
c. Between 15 cm and 30 cm
d. Between 0 cm and 15 cm

Q 10. When you focus the image of a distant flag, whose shape is given below, on a screen using a convex lens, the shape of the image as it appears on the screen is: *(CBSE 2017)*



a.



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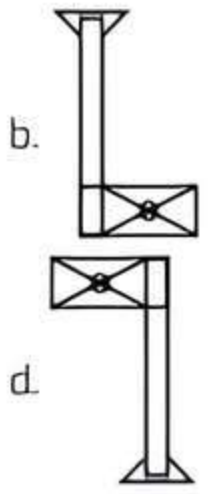


c.

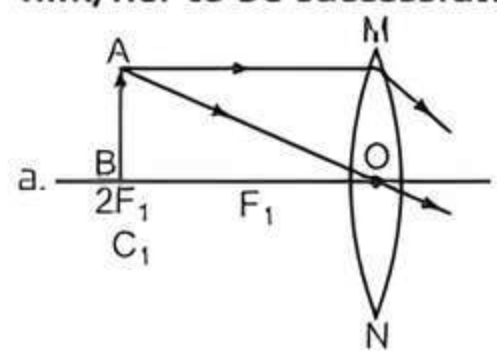
d.

Q 11. Which of the following can make a parallel beam of light when light from a point source is incident on it? *(CBSE SQP 2021 Term-1)*

a. Concave mirror as well as convex lens.
b. Convex mirror as well as concave lens.
c. Two plane mirrors placed at 90° to each others.
d. Concave mirror as well as concave lens.

Q 12. A student wants to obtain magnified image of an object AB as on a screen. Which one of the following arrangements shows the correct position of AB for him/her to be successful? *(CBSE 2021 Term-1)*

a.



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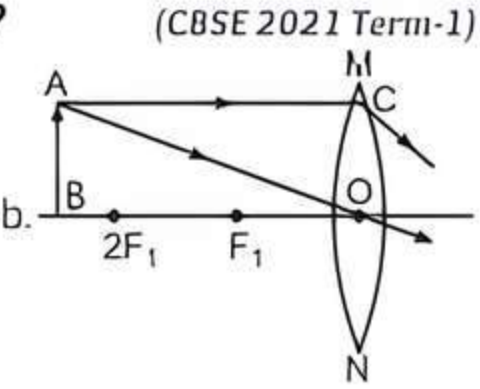

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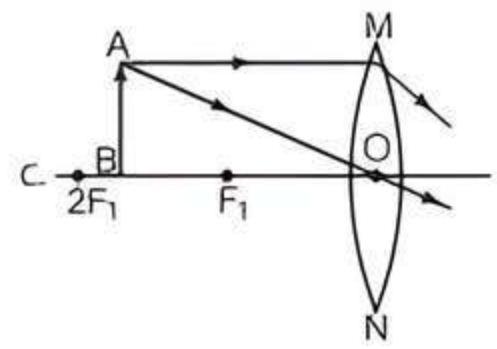

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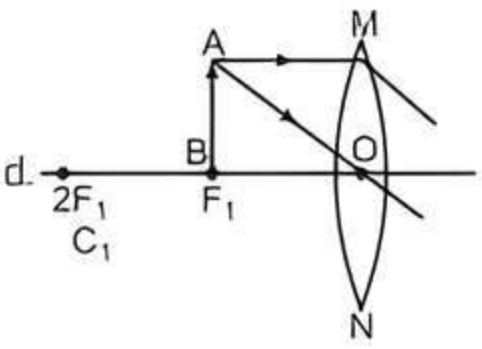
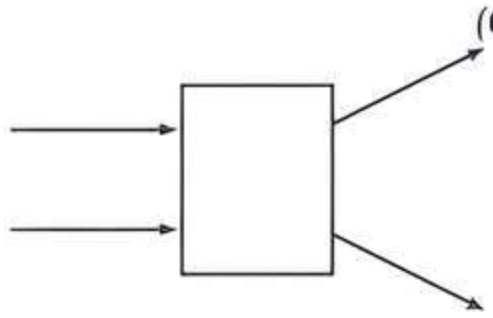


Q 13. The following diagram shows the use of an optical device to perform an experiment of light. As per the arrangement shown, the optical device is likely to be a: *(CBSE 2021 Term-1)*



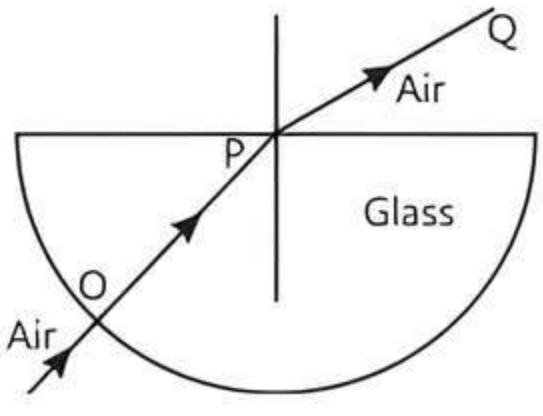
a. concave mirror b. concave lens
c. convex mirror d. convex lens

Q 14. If the real image of a candle flame formed by a lens is three times the size of the flame and the distance between lens and image is 80 cm, at what distance should the candle be placed from the lens?

(CBSE SQP 2021 Term-1)

a. –80 cm b. –40 cm c. –40/3 cm d. –80/3 cm

Q 15.



The angle of incidence from air to glass at the point O on the hemispherical glass slab is:

(CBSE SQP 2021 Term-1)

a. 45°
b. 0°
c. 90°
d. 180°

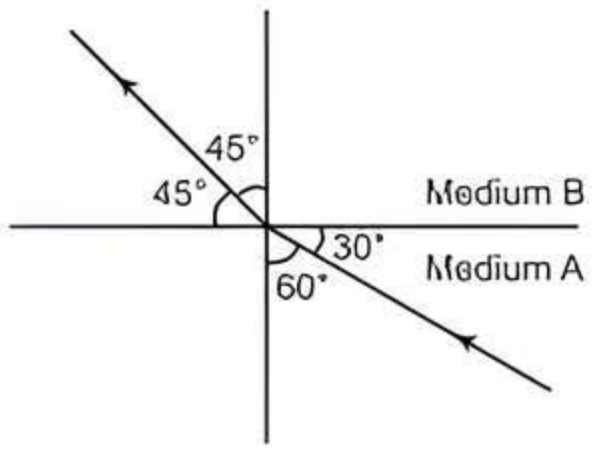
Q 16. A ray of light starting from air passes through medium A of refractive index 1.50, enters medium B of refractive index 1.33 and finally enters medium C of refractive index 2.42. If this ray emerges out in air from C, then for which of the following pairs of media the bending of light is least?

(CBSE 2021 Term-1)

a. air- A
b. A-B
c. B-C
d. C-air

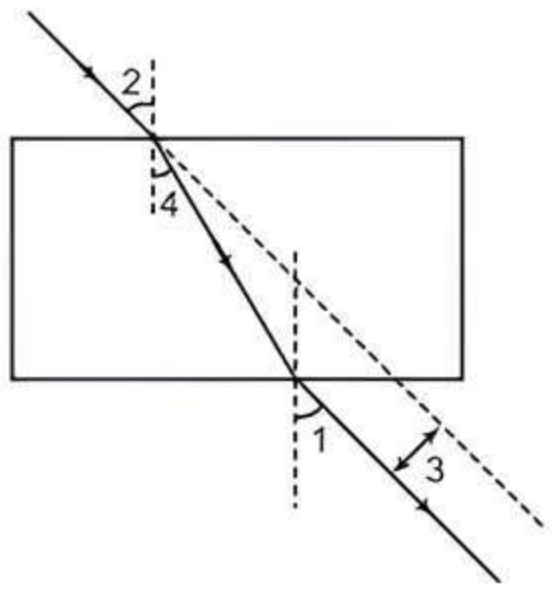
Q 17. The given figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is:

(NCERT EXEMPLAR)



a. $\sqrt{3}/\sqrt{2}$
b. $\sqrt{2}/\sqrt{3}$
c. $1/\sqrt{2}$
d. $\sqrt{2}$

Q 18. The correct sequencing of angle of incidence, angle of emergence, angle of refraction and lateral displacement shown in the following diagram by digits 1, 2, 3 and 4 is: *(CBSE 2017)*

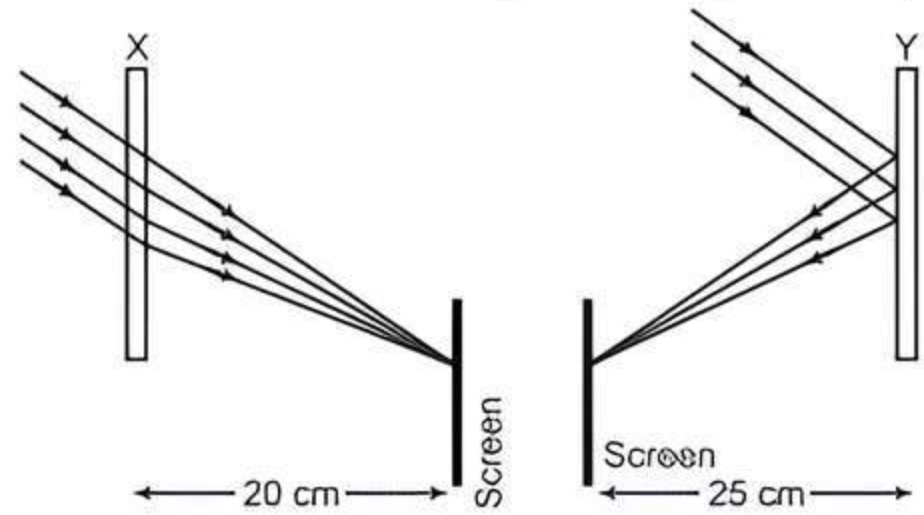


a. 2. 4. 1. 3
b. 2. 1. 4. 3
c. 1. 2. 4. 3
d. 2. 1. 3. 4

Q 19. A student obtains a blurred image of a distant object on a screen using a convex lens. To obtain a distinct image on the screen, he should move the lens: *(CBSE 2017)*

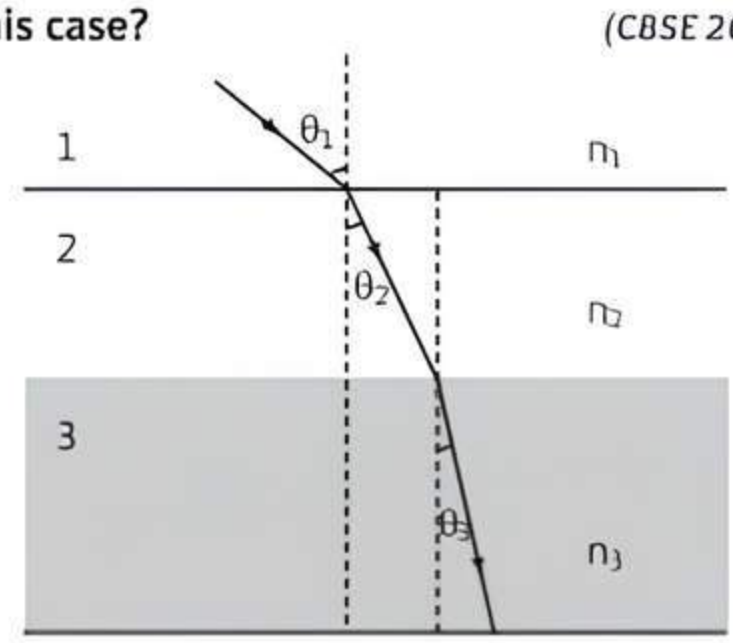
a. away from the screen
b. towards the screen
c. to a position very far away from the screen
d. either towards or away from the screen depending upon the position of the object

Q 20. Study the given ray diagrams and select the correct statement from the following: *(CBSE 2017)*



a. Device *X* is a concave mirror and device *Y* is a convex lens, whose focal lengths are 20 cm and 25 cm respectively.
b. Device *X* is a convex lens and device *Y* is a concave mirror, whose focal lengths are 10 cm and 25 cm respectively.
c. Device *X* is a concave lens and device *Y* is a convex mirror, whose focal lengths are 20 cm and 25 cm respectively.
d. Device *X* is a convex lens and device *Y* is a concave mirror, whose focal lengths are 20 cm and 25 cm respectively.

Q 21. In the diagram shown below n_1, n_2 and n_3 are refractive indices of the media 1, 2 and 3 respectively. Which one of the following is true in this case? *(CBSE 2021 Term-1)*



a. $n_1 = n_2$
b. $n_1 > n_2$
c. $n_2 > n_3$
d. $n_3 > n_1$

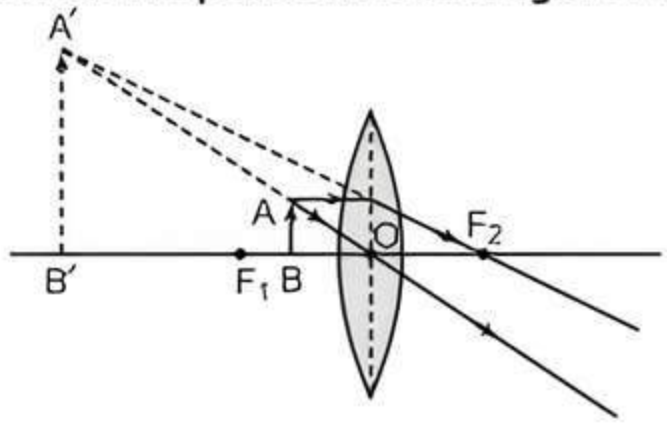
Q 22. The refractive index of medium A is 1.5 and that of medium B is 1.33. If the speed of light in air is 3×10^8 m/s, what is the speed of light in medium A and B respectively? *(CBSE 2021 Term-1)*

a. 2×10^8 m/s and 1.33×10^8 m/s
b. 1.33×10^8 m/s and 2×10^8 m/s
c. 2.25×10^8 m/s and 2×10^8 m/s
d. 2×10^8 m/s and 2.25×10^8 m/s

Q 23. The refractive index of flint glass is 1.65 and that for alcohol is 1.36 with respect to air. What is the refractive index of the flint glass with respect to alcohol? *(CBSE SQP 2021 Term-1)*

a. 0.82
b. 1.21
c. 1.11
d. 1.01

Q 24. The given lens has a focal length of 10 cm. The object of height 2 mm is placed at a distance of 5 cm from the pole. Find the height of the image.



a. 4 cm b. 6.67 mm c. 4 mm d. 3.33 mm

Q 25. Consider these indices of refraction: glass: 1.52; air: 1.0003; water: 1.333. Based on the refractive indices of three materials, arrange the speed of light through them in decreasing order.

(CBSE SQP 2021 Term-1)

a. The speed of light in water > the speed of light in air > the speed of light in glass.
b. The speed of light in glass > the speed of light in water > the speed of light in air.
c. The speed of light in air > the speed of light in water > the speed of light in glass.
d. The speed of light in glass > the speed of light in air > the speed of light in water.

Assertion & Reason Type Questions

Directions (Q. Nos. 26-30): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 26. Assertion (A): A ray incident along normal to the mirror retraces its path.

Reason (R): In reflection, angle of incidence is always equal to angle of reflection.

Q 27. Assertion (A): Large concave mirrors are used to concentrate sunlight to produce heat in solar cookers.

Reason (R): Concave mirror converges the light rays falling on it to a point.

Q 28. Assertion (A): A pencil partly immersed in water appears to be bent at the water surface.

Reason (R): Light from different points on the pencil immersed in water refracts and appears to come from a point above the original position.

Q 29. Assertion (A): Higher is the refractive index of a medium or denser the medium, lesser is the velocity of light in that medium.

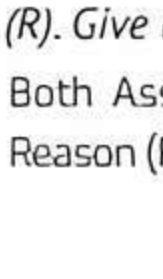
Reason (R): Refractive index is inversely proportional to velocity.

Q 30. Assertion (A): A convex lens can form a magnified erect as well as magnified inverted image of an object placed in front of it.

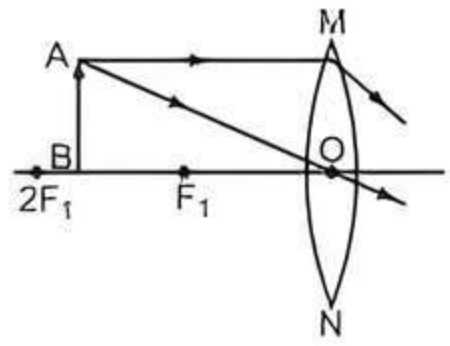
Reason (R): A magnified and inverted image can be obtained by a convex lens when an object is kept between F and C.

Answers

1. (d) all reflecting surfaces
2. (d) virtual and erect
3. (a) Only A
4. (b) very near to the focus of the reflector
5. (d) behind the mirror and it's position varies according to the object distance.
6. (d) +, +
7. (b) Sign – Positive. Value – More than 1
8. (b) When object is placed at centre of curvature, image is formed at the centre of curvature. *i.e.*; $m = -1$.
9. (d) Between 0 cm and 15 cm
10. (a)



11. (a) When light rays from a point source is incident on concave mirror and convex lens, emergent beams are parallel and the image is formed at infinity. Convex mirror and concave lens on the other hand always form a virtual image. Emergent beams from these are not parallel but diverging when the object is kept at focus.
12. (c)



13. (b) concave lens
14. (d) –80/3cm

Given. $m = -3$
$v = 80$ cm

We know that. $m = \frac{v}{u}$

$$-3 = \frac{80}{u}$$

$$u = \frac{80}{-3} = \frac{-80}{3} \text{ cm}$$

15. (b) for a normal incident light on the surface.
$\angle i = 0$
16. (b) A-B
17. (a) The Snell's law simply relates $\angle i$ and $\angle r$ to the refraction indices of two medium A and B.

Therefore, refractive index of medium B relative to medium A is

$$n = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 45°} = \frac{\sqrt{3}}{\sqrt{2}}$$

18. (b) From the figure, angle 2 is angle of incidence, as it is formed between the incident ray and the normal. Angle 1 is angle of emergence, as it is formed between the emergent ray with normal. Angle 4 is angle of refraction as it is formed between the refracted ray and the normal. 3 shows the lateral displacement. Hence, the correct answer is 2 , 1 , 4, 3.

19. (d) either towards or away from the screen depending upon the position of the object.

20. (d) Device *X* is a convex lens and device *Y* is a concave mirror, whose focal lengths are 20 cm and 25 cm respectively.

21. (d) $n_3 > n_1$

22. (d) Given, $c = 3 \times 10^8$ m/s

Refractive index of medium $A(\mu_A) = 1.5$

$\therefore$ Speed of light of medium $A = \frac{c}{\mu_A}$

$$= \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ m/s}$$

and refractive index of medium B $(\mu_B) = 1.33$

$\therefore$ Speed of light of medium B

$$= \frac{c}{\mu_B} = \frac{3 \times 10^8}{1.33} = 2.25 \times 10^8 \text{ m/s}$$

23. (b) Refractive index of flint glass w.r.t. alcohol

$$= \frac{\text{Refractive index of flint glass}}{\text{Refractive index of alcohol}}$$

$$= \frac{1.65}{1.36} = 1.21$$

24. (c) Given, $f = +10$ cm (Convex lens)

$h_1 = 2$ mm $= 0.2$ cm,

$u = -5$ cm

$$\frac{1}{f} = \frac{1}{v} - \left(\frac{1}{-5}\right)$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{5} \Rightarrow \frac{1-2}{10} = \frac{-1}{10}$$

$v = -10$ cm

Also, $m = \frac{v}{u} = \frac{h_2}{h_1} \Rightarrow m = \frac{-10}{-5} = \frac{h_2}{0.2}$

$\Rightarrow h_2 = 0.4$ cm

$\Rightarrow h_2 = 4$ mm

25. (c) The speed of light in air > the speed of light in water > the speed of light in glass.
Higher the refractive index, lesser is the speed of light in that medium and *vice-versa*.

26. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

27. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

28. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

29. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

30. (c) Assertion (A) is true but Reason (R) is false.

Case Study Based Questions

Case Study 1

A compound microscope is an instrument which consists of two lenses L_1 and L_2. The lens L_1 called objective, forms a real, inverted and magnified image of the given object. This serves as the object for the second lens L_2, the eye piece. The eye piece functions like a simple microscope or magnifier. It produces the final, image, which is inverted with respect to the original object, enlarged and virtual.

(CBSE 2021 Term-1)

Read the above passage carefully and give the answer of the following questions:

Q 1. What types of lenses must be L_1 and L_2?

a. Both concave
b. Both convex
c. L_1—concave and L_2—convex
d. L_1—convex and L_2—concave

Q 2. What is the value and sign of magnification (according to the new Cartesian sign convention) of the image formed by L_1?

a. Value = Less than 1 and Sign = Positive
b. Value = More than 1 and Sign = Positive
c. Value = Less than 1 and Sign = Negative
d. Value = More than 1 and Sign = Negative

Q 3. What is the value and sign of (according to new Cartesian sign convention) magnification of the image formed by L_2?

a. Value = Less than 1 and Sign = Positive
b. Value = More than 1 and Sign = Positive
c. Value = Less than 1 and Sign = Negative
d. Value = More than 1 and Sign = Negative

Q 4. If power of the eyepiece (L_2) is 5 diopters and it forms an image at a distance of 80 cm from its optical centre, at what distance should the object be?

a. 12 cm b. 16 cm c. 18 cm d. 20 cm

Answers

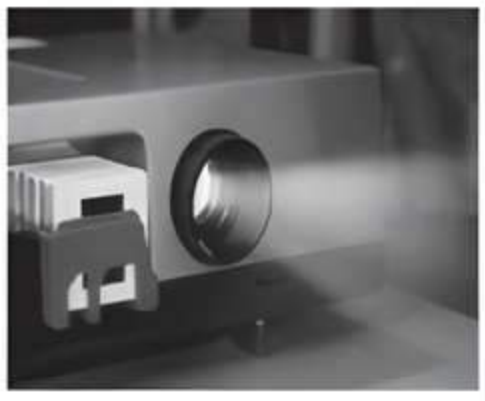
1. (b) Both convex

2. (d) Value = More than 1 and Sign = Negative

3. (b) Value = More than 1 and Sign = Positive

4. (b) 16 cm

Case Study 2



The above images are that of a specialised slide projector. Slides are small transparencies mounted in sturdy frames ideally suited to magnification and projection, since they have a very high resolution and a high image quality. There is a tray where the slides are to be put into a particular orientation so that the viewers can see the enlarged erect images of the transparent slides. This means that the slides will have to be inserted upside down in the projector tray.

To show her students the images of insects that she investigated in the lab, Mrs. Iyer brought a slide projector. Her slide projector produced a 500 times enlarged and inverted image of a slide on a screen 10 m away.

Read the above passage carefully and give the answer of the following questions:

Q 1. Based on the text and data given in the above paragraph, What kind of lens must the slide projector have?

Q 2. If v is the symbol used for image distance and u for object distance, then with one reason, state what will be the sign for $\frac{v}{u}$ in the given case?

Q 3. A slide projector has a convex lens with a focal length of 20 cm. The slide is placed upside down 21 cm from the lens. How far away should the screen be placed from the slide projector's lens so that the slide is in focus?

Or

When a slide is placed 15 cm behind the lens in the projector, an image is formed 3 m in front of the lens. If the focal length of the lens is 14 cm, draw a ray diagram to show image formation. (not to scale) *[CBSE SQP 2022-23]*

Answers

1. Convex lens
2. Negative as the image is real and inverted.
3. $1/f = 1/v - 1/-21$

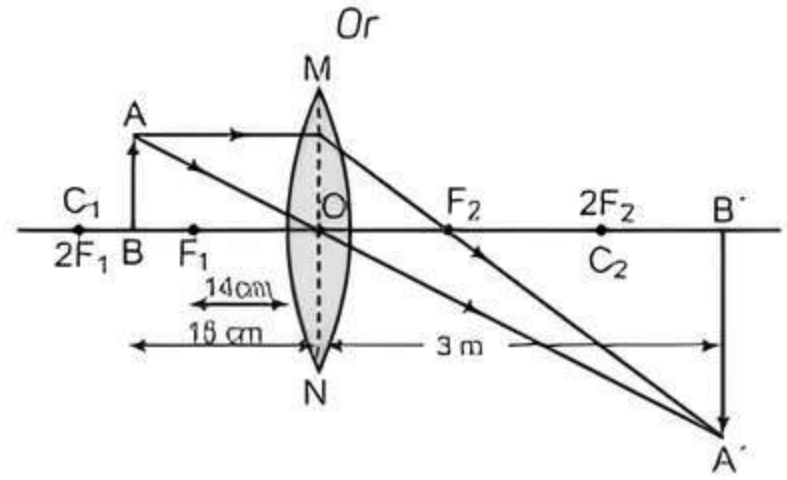
   $\Rightarrow \quad 1/20 = 1/v - 1/u$

   $\Rightarrow \quad 1/v = 1/20 - 1/21$

   $= (21 - 20)/420 = 1/420$

   $v = 420$ cm

Or



Case Study 3

Ravi wanted to fix the rear-view mirror of his scooter. He knows that rear-view mirror is an essential safety device in the vehicle and allows him to see objects at the backside of his vehicle.

He bought two mirrors M_1 and M_2, out of which M_1 is curved inwards and M_2 is curved outwards.

Read the above passage carefully and give the answer of the following questions:

Q 1. **Based on the given situation, which mirror should Ravi need to fix as his rear-view mirror and why?**

Q 2. Ravi did some preliminary experiment with mirror M_1 and found that magnification of the real image of an object placed at 10 cm in front of it is 3, at what distance is the image located?

Q 3. What is the formula for magnification obtained with a mirror?

Q 4. An object is placed at the centre of curvature of M_1. Find the distance between its image and pole.

Q 5. An object is placed 60 cm in front of M_2. The image formed by the mirror is located 30 cm behind the mirror. What is the object's magnification?

Answers

1. M_2 because it gives an erect and diminished image.
2. Given, $m = -3$ (image is real), $u = -10$

   We know that, $m = \frac{-v}{u} \Rightarrow -3 = \frac{-v}{-10}$

   $\Rightarrow \quad v = -30$ cm
3. Magnification $(m) = \frac{\text{Height of image } (h_i)}{\text{Height of object } (h_o)}$

   $= \frac{\text{Image distance } (-v)}{\text{Object distance } (u)}$
4. When object is at C of M_1 (concave mirror), image is formed at C, *i.e.*, $v = -C = -2f$

   Hence, distance between image and pole is $2f$.

5. Given, $u = -60$ cm and $v = 30$ cm

We know that, $m = -v/u$

$$= \frac{-30}{-60}$$

$$= \frac{1}{2} \text{ or } +0.5$$

Case Study 4

The ability of a medium to refract light is expressed in terms of its optical density. Optical density has a definite connotation. It is not the same as mass density. On comparing two media, the one with the large refractive index is optically denser medium than the other. The other medium with a lower refractive index is optically rarer. Also the speed of light through a given medium is inversely proportional to its optical density.

Read the above passage carefully and give the answer of the following questions:

Q 1. Determine the speed of light in diamond if the refractive index of diamond with respect to vacuum is 2.42. Speed of light in vacuum is 3×10^8 m/s.

Q 2. Refractive indices of glass, water and carbon disulphide are 1.5, 1.33 and 1.62 respectively. If a ray of light is incident in these media at the same angle (say θ), then write the increasing order of the angle of refraction in these media.

Q 3. The speed of light in glass is 2×10^8 m/s and in water is 2.25×10^8 m/s.

(i) Which one of the two is optically denser and why?

(ii) A ray of light is incident normally at the water-glass interface when it enters a thick glass container filled with water. What will happen to the path of the ray after entering the glass? Give reason.

Or

The absolute refractive indices of water and glass are 4/3 and 3/2 respectively. If the speed of light in glass is 2×10^8 m/s, find the speed of light in (i) vacuum and (ii) water. *[CBSE 2023]*

Answers

1. Given, $\mu = 2.42$, $c = 3 \times 10^8$ m/s

Speed of light in diamond $= \frac{c}{\mu} = \frac{3 \times 10^8}{2.42}$

$= 1.24 \times 10^8$ m/s

2. Carbon disulphide, glass, water.

3. (i) Glass is denser than water because speed of light in glass is less than that of water.

(ii) A ray of light incident normally at the water-glass interface does not suffer any refraction and goes straight on entering the thick glass container filled with water. This is so because all parts of the light waves reach the interface at the same time, enter the glass at the same time and hence get slowed down at the same time.

Or

Given, $\mu_w = \frac{4}{3}$, $\mu_g = \frac{3}{2}$, $v_g = 2 \times 10^8$ m/s

We know that

$$\text{Speed of light in medium} = \frac{c}{\mu}$$

where, c = speed of light in vacuum

μ = refractive index of medium

(i) $\therefore$ c = speed of light in glass × refractive index of glass

$= v_g \times \mu_g$

$= 2 \times 10^8 \times \frac{3}{2}$

$= 3 \times 10^8$ m/s

(ii) Speed of light in water $= \frac{c}{\text{refractive index of water}}$

$= \frac{c}{\mu_w}$

$= \frac{3 \times 10^8}{4/3}$

$= 2.25 \times 10^8$ m/s

Very Short Answer Type Questions

Q 1. What is the magnification of the images formed by plane mirrors and why? *(CBSE 2015)*

Ans. The magnification of the images formed by plane mirrors is 1 because the size of the image is equal to the size of object.

Q 2. What is the radius of curvature of a plane mirror? *(CBSE 2015)*

Ans. The radius of curvature of a plane mirror is infinity.

Q 3. How can a concave mirror be identified without touching? *(CBSE 2020)*

Ans. If the object is placed close to the mirror, the image will be erect and magnified.

Q 4. Define pole of a spherical mirror. *(CBSE 2020)*

Ans. The centre of the reflecting surface of a spherical mirror is a point called the pole.

Q 5. The radius of curvature of a spherical mirror is 20 cm. What is its focal length?

Ans. Focal length, $f = R/2 = 20/2 = 10$ cm

Q 6. What are the advantage and disadvantage of using a convex mirror for seeing traffic at the rear? *(CBSE 2015)*

Ans. **Advantage:** Convex mirror always gives an erect image and has a wider field of view.

Disadvantage: It does not give the correct distance of the vehicle at the rear.

Q 7. State the cause of refraction of light.

Ans. The cause of the refraction of light is that light travels at different speeds in different media.

Q 8. A ray of light falls normally on a face of a glass slab. What are the values of angle of incidence and angle of refraction of this ray?

Ans. When a ray of light falls on a glass slab normally then, $\angle i = 0$ and $\angle r = 0$.

Q 9. If the image formed by a convex lens is of the same size as that of the object. What is the position and nature of the image with respect to the lens?

Ans. The image will be real and inverted and will be formed at the centre of curvature of the lens.

Q 10. What is the minimum number of rays required for locating an image formed by a concave lens for an object?

Ans. We require minimum two rays for locating an image formed by a concave lens for an object.

Q 11. If on applying Cartesian sign convention for spherical lenses, the image distance obtained is negative, state the significance of the negative sign.

Ans. This means that the image is formed at the same side of the object. *i.e.*, virtual and erect. Also, the lens is concave in nature.

Q 12. A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

Ans. $f = \frac{1}{P}\text{m} = \frac{1}{+1.5}\text{m} = +\frac{10}{15}\text{m} = +\frac{2}{3}\text{m}$

$+f$ means that the lens is convex or diverging in nature.

Short Answer Type-I Questions ↘

Q 1. State the laws of reflection. *(CBSE 2019)*

Ans. Laws of Reflection:

(i) The angle of incidence is equal to the angle of reflection, and

(ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.

Q 2. List four characteristics of the image formed by a concave mirror of focal length 40 cm when the object is placed in front of it at a distance of 20 cm from its pole. *(CBSE 2019)*

Ans.

TiP

Here, object distance = 20 cm and focal length = 40 cm, i.e., object is placed between pole and focus of the concave mirror.

Four characteristics of image formed by the given concave mirror are:

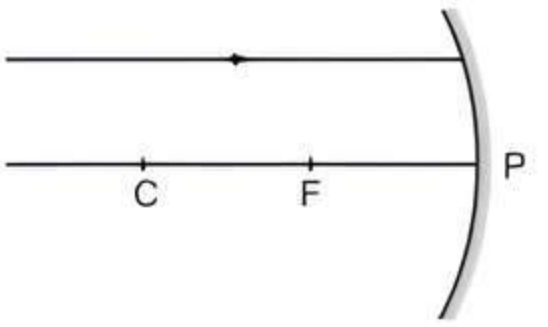
(i) Image is virtual

(ii) Image is erect

(iii) Image is enlarged/magnified

(iv) Image is formed behind the mirror.

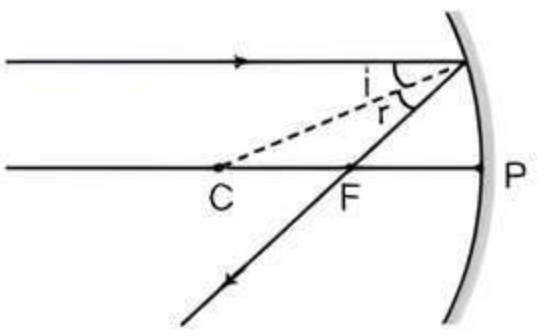
Q 3. Redraw the following diagram on your answer-sheet and show the path of the reflected ray. Also mark the angle of incidence ($\angle i$) and the angle of reflection ($\angle r$) on the diagram: *(CBSE 2017)*



Ans.

TiP

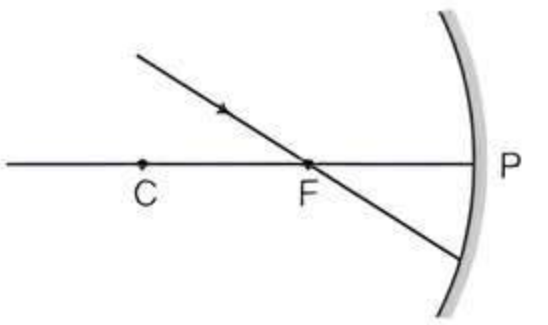
A ray parallel to the principal axis, after reflection, will pass through the principal focus of concave mirror.



COMMON ERROR

Usually students forget to label the angle of incidence and angle of reflection.

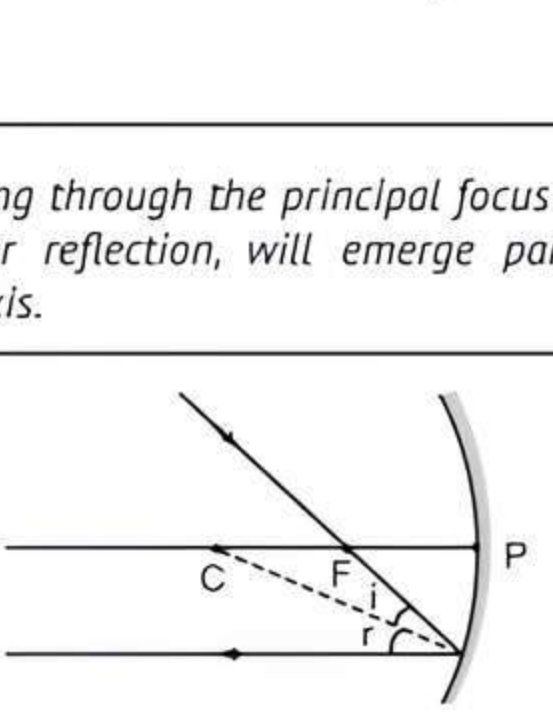
Q 4. Redraw the following diagram on your answer-sheet and show the path of the reflected ray. Also mark the angle of incidence ($\angle i$) and the angle of reflection ($\angle r$) on the diagram: *(CBSE 2017)*



Ans.

TiP

A ray passing through the principal focus of a concave mirror, after reflection, will emerge parallel to the principal axis.



Q 5. An object is placed at a distance of 30 cm in front of a convex mirror of focal length 15 cm. Write four characteristics of the image formed by the mirror. *(CBSE 2017)*

Ans. Four characteristics of image formed by the given convex mirror are:

(i) Image is virtual (ii) Image is erect

(iii) Image is diminished

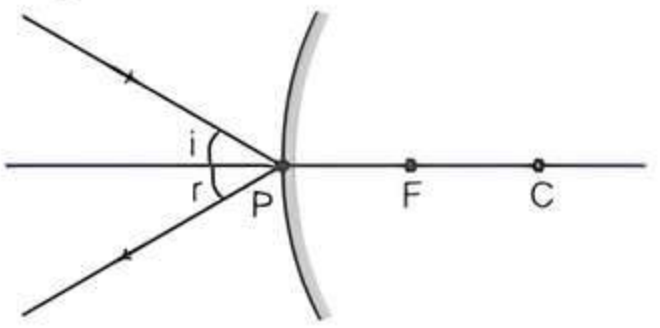
(iv) Image is formed between P and F, i.e., behind the mirror.

COMMON ERROR

Usually students get confused between convex and concave mirror and write characteristics of image formed by concave mirror.

Q 6. Draw a labelled ray diagram to show the path of the reflected ray corresponding to the ray which is incident obliquely to the principal axis, towards the pole of a convex mirror. Mark the angle of incidence and angle of reflection on it. *(CBSE 2019)*

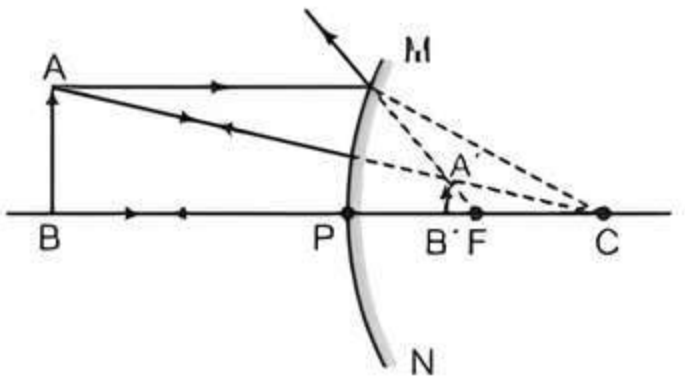
Ans. Ray Diagram:



Q 7. If the image formed by a spherical mirror for all positions of the object placed in front of it is always erect and diminished, what type of mirror is it ? Draw a labelled ray diagram to support your answer. *(CBSE 2017)*

Ans. The mirror is convex mirror.

Ray Diagram:



COMMON ERROR

Students forget to mark the arrows on the rays to indicate their direction of travel.

Q 8. An object of height 1.2 cm is placed before a concave mirror of focal length 20 cm so that a real image is formed at a distance of 60 cm from it. Find the position of an object. What will be the height of the image formed?

Sol. Given that, $h_o = 1.2$ cm, $f = -20$ cm and $v = -60$ cm

Using mirror formula,

$$\frac{1}{u} = \frac{1}{f} - \frac{1}{v}$$

$$\frac{1}{u} = \frac{1}{-20} - \frac{1}{-60}$$

$$u = -60/2 = -30 \text{ cm}$$

We know that,

$$\frac{h_i}{h_o} = \frac{-v}{u}$$

$$h_i = \frac{-60}{-30} \times 1.2 = -2.4 \text{ cm}$$

Q 9. State laws of refraction of light. *(CBSE 2019)*

Ans. Laws of refraction of light:

(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

(ii) The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction.

Q 10. Define absolute refractive index and express it mathematically. *(CBSE 2019)*

Ans. Refractive index of a transparent medium with respect to vacuum or air is called absolute refractive index.

Mathematically,

Absolute refractive index of a medium (μ)

$$= \frac{\text{Speed of light in vacuum or air } (c)}{\text{Speed of light in the medium } (v)}$$

Q 11. The absolute refractive index of Ruby is 1.7. Find the speed of light in Ruby. The speed of light in vacuum is 3×10^8 m/s. *(CBSE 2019)*

Sol. We know that,

$$\mu = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in Ruby}} = \frac{c}{v}$$

or $v = c/\mu$

where, c = velocity of light and μ = refractive index

$$v = \frac{3 \times 10^8}{1.7} = 1.76 \times 10^8 \text{ m/s}$$

Q 12. The refractive indices of three media are given below:

Medium	Refractive Index
A	1.6
B	1.8
C	1.5

A ray of light is travelling from A to B and another ray is travelling from B to C.

(i) In which of the two cases the refracted ray bends towards the normal?

(ii) In which case does the speed of light increase in the second medium?

Give reasons for your answer. *(CBSE SQP 2023-24)*

Ans.

TiP

In comparing two media, the one with the larger refractive index is optically denser medium than the other. The other medium of lower refractive index is optically rarer.

Out of media A and B,

A is optically rarer medium and

B is optically denser medium $(\because \mu_B > \mu_A)$

Similarly, out of media B and C,

B is optically answer medium and

C is optically rarer medium $(\because \mu_B > \mu_C)$

(i) We know that a ray of light travelling from a rarer to denser medium bends towards the normal. Hence, ray of light travelling from A to B will bend towards the normal.

(ii) We know that when a ray of light travels from a denser medium to a rarer medium, it speeds up. Hence, the speed of light will increase when it travels from B to C.

Q 13. For the same angle of incidence in media A, B and C, the angles of refraction are 20°, 30° and 40° respectively. In which medium will the velocity of light be maximum? Give reason in support of your answer.

Ans. From Snell's law,

$$\mu = \frac{\sin i}{\sin r} = \frac{c}{v}$$

Since c and $\sin i$ are constant therefore

$$\sin r \propto v.$$

Therefore, velocity of light is maximum in medium C.

Q 14. An object is placed at a distance of 15 cm from a convex lens of focal length 20 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. *(CBSE 2017)*

Ans. Four characteristics of image formed by the given convex lens are:

(I) Image is virtual

(ii) Image is erect

(iii) Image is enlarged

(iv) Image is formed on the same side of the lens as the object.

Q 15. An object is placed at a distance of 15 cm from a concave lens of focal length 30 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. *(CBSE 2017)*

Ans. Four characteristics of image formed by the given concave lens are:

(I) Image is virtual

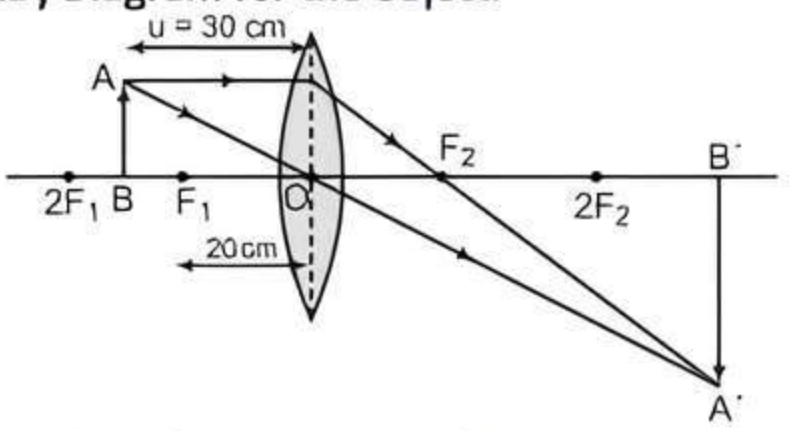
(ii) Image is erect

(iii) Image is diminished

(iv) Image is formed between focus F_1 and optical centre O, *i.e.*, on the same side of the lens as the object.

Q 16. An object of height 4.0 cm is placed at a distance of 30 cm from the optical centre 'O' of a convex lens of focal length 20 cm. Draw a ray diagram to find the position and size of the image formed. Mark optical centre 'O' and principal focus 'F' on the diagram. Also find the ratio of size of the image to the size of the object. *(CBSE 2018)*

Ans. Ray Diagram for the Object:



Position of image: Beyond $2F_2$

Size of image: Enlarged

Given, $h_o = 4.0$ cm,

$u = -30$ cm

and $f = 20$ cm

Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \left(\frac{1}{-30}\right) = \frac{1}{20}$$

$$\Rightarrow \quad \frac{1}{v} + \frac{1}{30} = \frac{1}{20}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}$$

$$\Rightarrow \quad v = 60 \text{ cm}$$

Now, $$m = \frac{h_I}{h_o} = \frac{v}{u} = \frac{60}{-30}$$

$$\Rightarrow \quad h_I/h_o = -2/1$$

Q 17. The power of a lens is +5 diopters. What is the nature and focal length of this lens? At what distance from this lens should an object be placed so as to get its inverted image of the same size? *(CBSE 2019)*

Ans. Given, $P = +5$ D

We know that, $f = 100/P = 100/5 = +20$ cm

$+f$ indicates that the lens is convex (converging) in nature.

Object should be placed at a distance of 40 cm (at $2F_1$) from the given convex lens to obtain an inverted image of same size.

Short Answer Type-II Questions

Q 1. Define the following terms in the context of a diverging mirror:

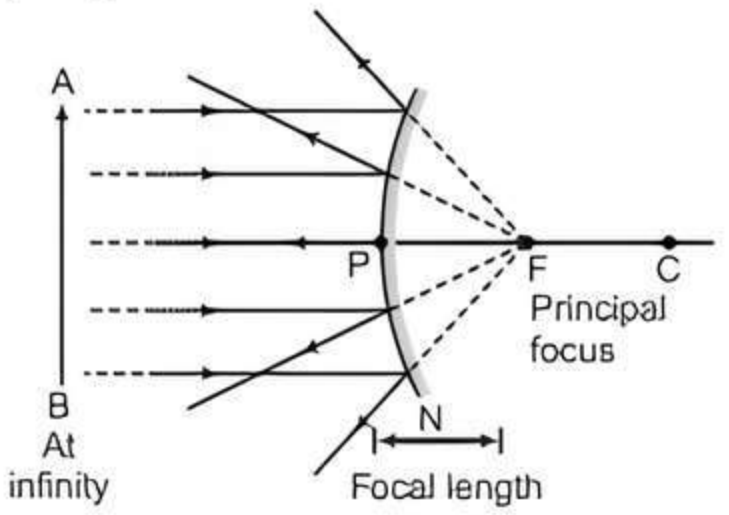
(i) Principal focus (ii) Focal length

Draw a labelled ray diagram to illustrate your answer. *(CBSE 2023)*

Ans. (I) The principal focus of a diverging (convex) mirror is a point on its principal axis from which a beam of light rays, initially parallel to the axis, appears to diverge after being reflected from the convex mirror.

(II) The distance between the pole and the principal focus of diverging mirror is called focal length of diverging (convex) mirror.

Ray Diagram:



Q 2. A child is standing in front of a magic mirror. She finds the image of her head bigger, the middle portion of her body of the same size and that of the legs smaller. Explain the construction of the magic mirror using different types of mirrors. Also state the reasons in support of your answer. *(CBSE 2020)*

Ans. The top part of the mirror is concave because it forms enlarged, erect and virtual image when the object is closer to the mirror.

The middle part is a plane mirror because it forms image of the same size.

The lower part is a convex mirror because it forms erect and diminished image.

TiP

Students should learn the image formation by plane, convex and concave mirrors.

Q 3. A student holding a mirror in his hand, directed the reflecting surface of the mirror towards the Sun. He then directed the reflected light on to a sheet of paper held close to the mirror.

(i) What should he do to burn the paper?

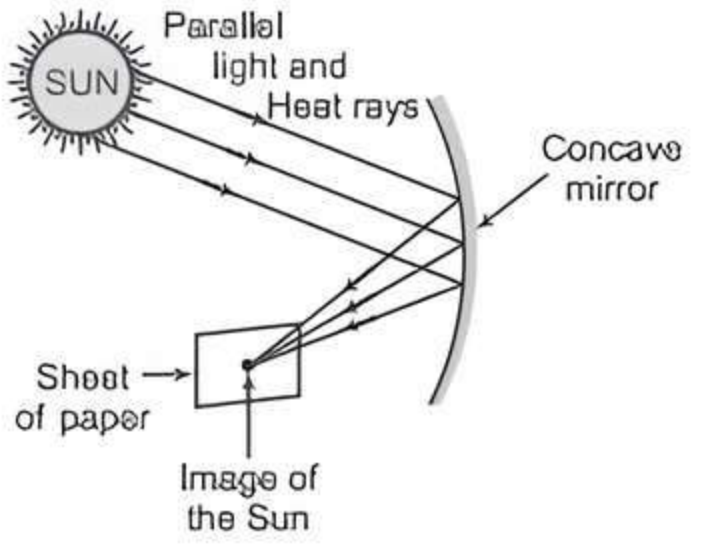
(ii) Which type of mirror does he have?

(iii) Will he be able to determine the approximate value of focal length of this mirror from this activity? Give reason and draw ray diagram to justify your answer in this case. *(CBSE 2019)*

Ans. (i) To burn the paper, student should move the mirror/sheet of paper to focus the rays at one point, *i.e.*, at the focus of the mirror.

(ii) Student is having a converging type of mirror that is a concave mirror.

(iii) Yes, he can measure the approximate value of focal length from this activity. The distance between mirror and focal point gives approximate focal length.



Q 4. Name the type of mirror which facilitates:

(i) Shaving,

(ii) Observing large images of the teeth of a patient, and

(iii) Observing the rear view in vehicles.

Give reason to justify your answer in each case. *(CBSE 2020)*

Ans. (i) Concave mirror facilitates shaving because when the face is held within the focus of concave mirror, then an erect and enlarged image of the face is seen in it.

(ii) Concave mirrors are used for observing large images of the teeth of a patient because they produce enlarged and erect images.

(iii) Convex mirrors are used as rear-view (wing) mirrors in vehicles because they have a wider field of view and give an erect image.

COMMON ERROR

Students get confused between the uses of concave and convex mirrors.

Q 5. Rohit wants to have an erect image of an object using a converging mirror of focal length 40 cm.

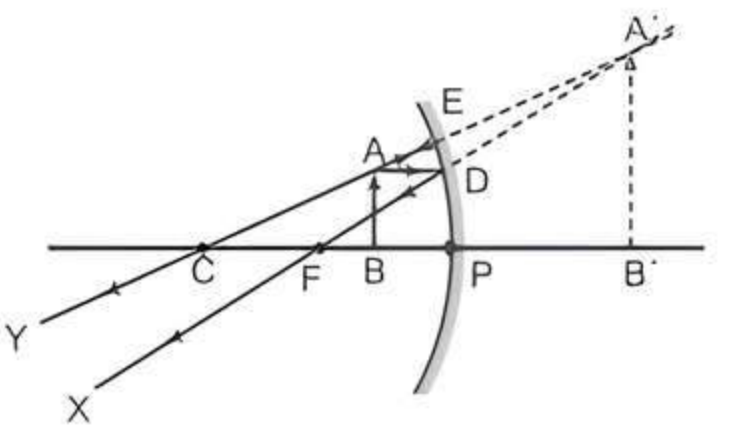
(i) Specify the range of distance where the object can be placed in front of the mirror. Justify.

(ii) Draw a ray diagram to show image formation in this case.

(iii) State one use of the mirror based on the above kind of image formation. *(CBSE SQP 2022-23)*

Ans. (i) The object has to be placed at a distance between 0 to 40 cm. This is because image is virtual, erect and magnified when the object is placed between F and P.

(ii)



(iii) Used as shaving mirror or used by dentists to get enlarged image of teeth.

Q 6. The magnification produced when an object is placed at a distance of 20 cm from a spherical mirror is + 1/2. Where should the object be placed to reduce the magnification to + 1/3? *(CBSE 2023)*

Ans.

TiP

While solving numericals, it is advisable that the formula should be written in the beginning.

Given, $u = -20$ cm, $m = +\frac{1}{2}$, $m' = +\frac{1}{3}$

We know that, $m = \frac{-v}{u} \Rightarrow \frac{1}{2} = \frac{-v}{-20} \Rightarrow v = +10$ cm

Using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{10} + \frac{1}{(-20)}$

$= \frac{2-1}{20} = \frac{1}{20}$

$\therefore \quad f = +20$ cm

Again, $m' = \frac{-v}{u} \Rightarrow \frac{+1}{3} = \frac{-v}{u} \Rightarrow v = -u/3$

Using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\Rightarrow \quad \frac{1}{20} = \frac{1}{\left(\frac{-4}{3}\right)} + \frac{1}{u} = \frac{-3}{u} + \frac{1}{u}$

$\Rightarrow \quad \frac{1}{20} = \frac{-3+1}{u} = \frac{-2}{u}$

$\Rightarrow \quad u = 20 \times -2$ or $u = -40$ cm

Thus, the object should be placed at a distance of 40 cm from the spherical mirror to reduce the magnification to + 1/3.

Q 7. A student has focussed the image of an object of height 3 cm on a white screen using a concave mirror of focal length 12 cm. If the distance of the object from the mirror is 18 cm, find the values of the following:

(i) Distance of the image from the mirror

(ii) Height of the image *(CBSE 2023)*

Ans. Given, $h_o = +3$ cm, $f = -12$ cm (concave mirror) and $u = -18$ cm

(i) Using mirror formula, $1/f = 1/v + 1/u$

$\therefore \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-12)} - \frac{1}{(-18)}$

$= \frac{-1}{12} + \frac{1}{18} = \frac{-3+2}{36} = \frac{-1}{36}$

$\therefore \quad v = -36$ cm

Therefore, distance of image from mirror is 36 cm.

(ii) We know that,

$m = \frac{-v}{u} = \frac{h_i}{h_o}$

$\Rightarrow \quad h_i = \frac{-v}{u} \times h_o = \frac{36}{-18} \times 3$

$= -6$ cm

Therefore, height of image is 6 cm.

Q 8. It is desired to obtain an erect image of an object, using concave mirror of focal length of 12 cm.

(i) What should be the range of the object distance in the above case?

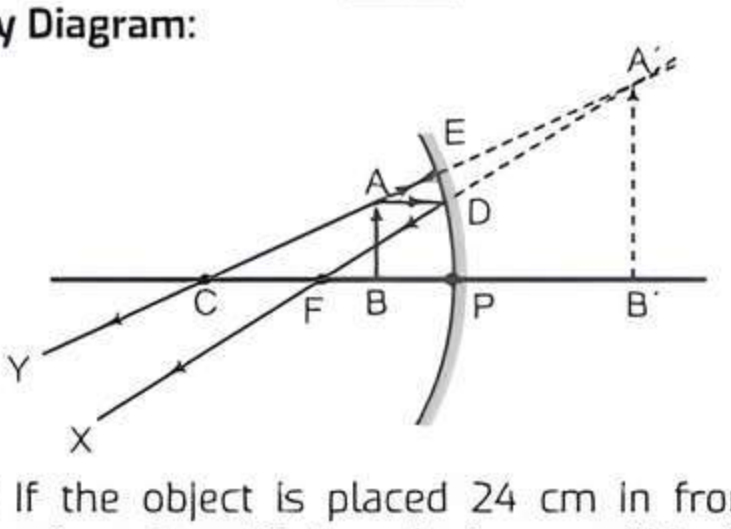
(ii) Will the image be smaller or larger than the object? Draw a ray diagram to show the formation of image in this case.

(iii) Where will the image of this object be, if it is placed 24 cm in front of the mirror?

Ans. (i) Range of object distance should be between 0 to 12 cm to obtain an erect image.

(ii) The image will be larger than the object.

Ray Diagram:



(iii) If the object is placed 24 cm in front of the mirror, *i.e.*, at C, then the image will be formed at the same position, *i.e.*, at C.

Q 9. A student wants to project the image of a candle flame on a screen 80 cm in front of a mirror by keeping the candle flame at a distance of 20 cm from its pole.

(i) Which type of mirror should the student use?

(ii) Find the magnification of the image produced.

(iii) Find the distance between the object and its image.

(iv) Draw a ray diagram to show the image formation in this case and mark the distance between the object and its image. *(CBSE 2015)*

Ans. Given that, $v = -80$ cm and $u = -20$ cm

(i) The student should use concave mirror because the image is real

(ii) Magnification,

$m = -\frac{v}{u} = -\frac{-80}{-20} = -4$

(iii) Distance between the object and its image

$= 80 - 20 = 60$ cm

Hence, the image is formed at a distance of 60 cm from the object.

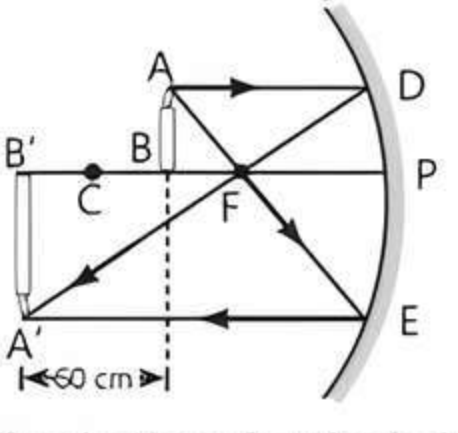
(iv) The focal length of the concave mirror can be calculated as follows:

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{-80} + \frac{1}{-20}$

$= -\frac{5}{80} = -\frac{1}{16}$

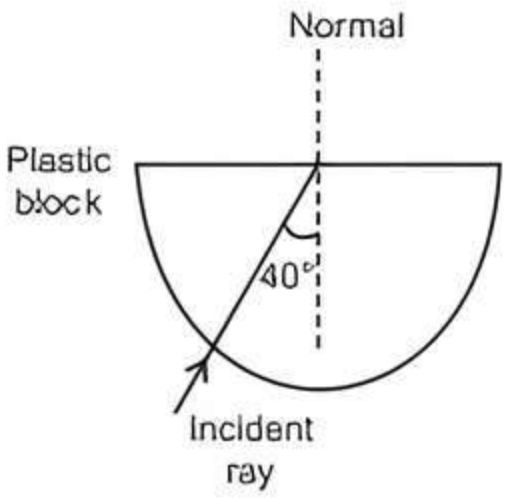
$\therefore \quad f = -16$ cm

Since, $u = -20$ cm, so the object lies between F and C.



Q 10. (i) Explain why the refractive index of any material with respect to air is always greater than 1.

(ii) In the given figure, a light ray travels from air into the semi-circular plastic block. Give a reason why the ray does not deviate at the semi-circular boundary of the plastic block.



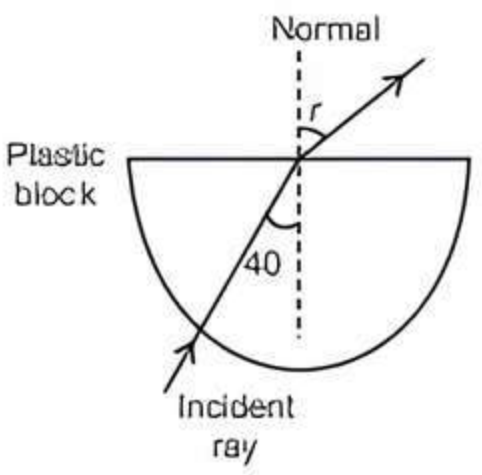
(iii) Complete the ray diagram of the above scenario when the light ray comes out of the plastic block from the top flat end. *(CBSE SQP 2023-24)*

Ans. (i) The refractive index of a medium with respect to air is given by $\frac{\text{speed of light in air}}{\text{speed of light in the medium}}$.

Since speed of light in the medium is always less than the speed of light in air, hence the above ratio is always greater than 1.

(ii) The ray of light is undergoing normal incidence at the air-plastic block interface. We know that if the incident ray falls normally, then there is no bending of the ray of light and it goes straight without any deviation.

(iii)



Q 11. (i) Water has refractive index 1.33 and alcohol has refractive index 1.36. Which of the two mediums is optically denser? Give reason for your answer.

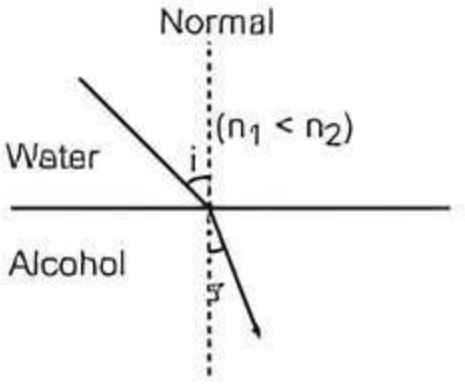
(ii) Draw a ray diagram to show the path of a ray of light passing obliquely from water to alcohol.

(iii) State the relationship between angle of incidence and angle of refraction in the above case. *(CBSE 2020)*

Ans. (i) Refractive index of alcohol is greater than refractive index of water. So, alcohol is optically denser than water.

(ii) When a ray of light enters from water to alcohol, it bends towards the normal.

(iii) Angle of incidence is greater than angle of refraction.



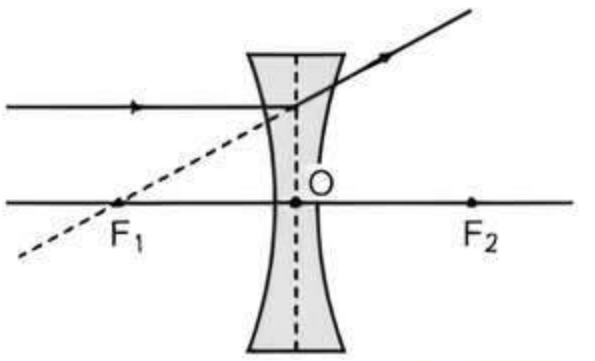
Q 12. What happens after refraction, when:

(i) a ray of light parallel to the principal axis passes through a concave lens?

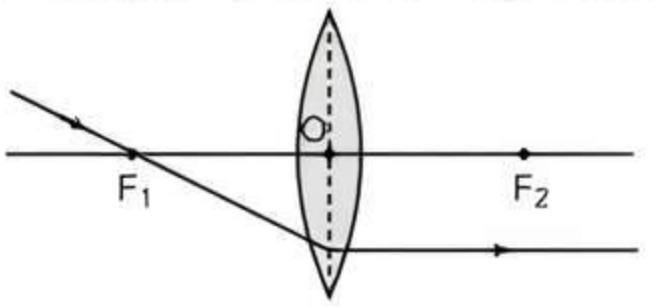
(ii) a ray of light falls on a convex lens while passing through its principal focus?

(iii) a ray of light passes through the optical centre of a convex lens ? *(CBSE 2020)*

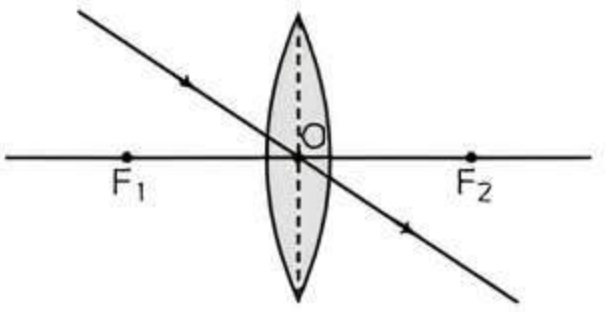
Ans. (i) It appears to be coming from focus after refraction through the lens.



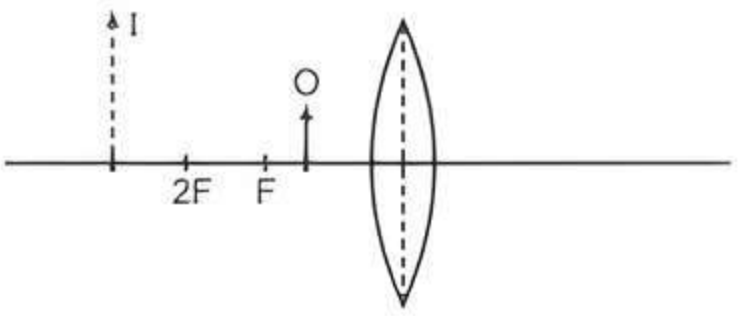
(ii) It will appear parallel to the principal axis.



(iii) It suffers no refraction *i.e.* it passes undeviated.



Q 13. The diagram given below shows an object *O* and its image *I*.



Without actually drawing the ray diagram, state the following:

(i) Type of lens (converging / diverging)

(ii) Name two optical instruments where such an image is obtained.

(iii) List three characteristics of the image formed if this lens is replaced by a concave mirror of focal length '*f*' and an object is placed at a distance '*f*/2' in front of the mirror. *(CBSE 2020)*

Ans.

TiP

Image formed by a concave (diverging) lens is always virtual and diminished in size. So, the given lens can't be diverging in nature as the given image is virtual but enlarged.

(i) Converging lens

(ii) In microscope and telescope

(iii) Three characteristics of the image formed by a concave mirror:

(a) Virtual and erect image

(b) Enlarged image

(c) Image will be formed behind the mirror

COMMON ERR(!)R

Students get confused between converging and diverging lens.

Q 14. "A lens can form a magnified erect image as well as magnified inverted image of an object placed in front of it." State the nature of this lens and draw ray diagrams to justify the above statement. Mark the positions of O, F and 2F in the diagram.

(CBSE 2017)

Or

Draw ray diagrams to show the formation of three times magnified (a) real, and (b) virtual image of an object by a converging lens. Mark the positions of O, F and 2F in each diagram. *(CBSE 2017)*

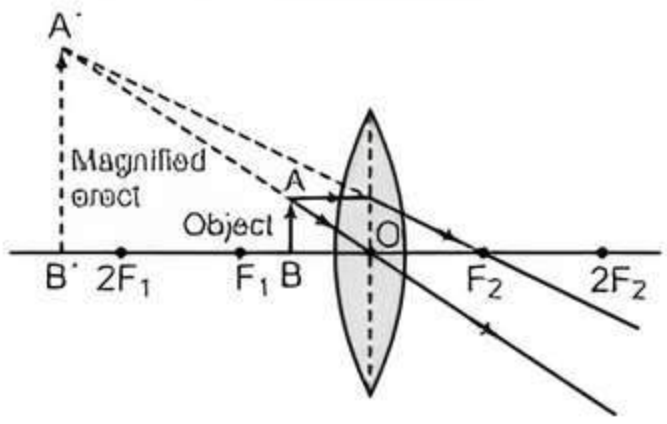
Ans.

TiP

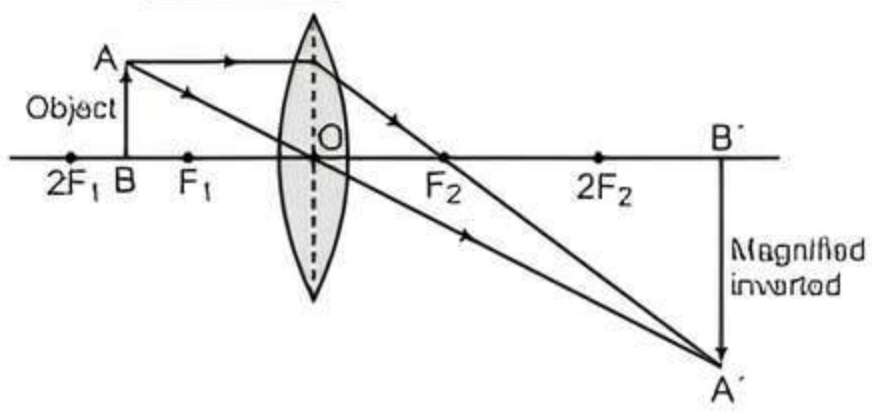
Practice drawing the ray diagrams carefully with proper labellings. Make sure that the arrows are properly marked.

The lens is convex in nature.

For magnified erect image: The object is placed between F_1 and optical centre O.



For magnified inverted image: The object is placed between F_1 and $2F_1$.



Q 15. The magnification of an image formed by a lens is −1. If the distance of the image from the optical centre of the lens is 25 cm, where is the object placed? Find the nature and focal length of the lens. If the object is displaced 15 cm towards the optical centre of the lens, where would the image be formed? Draw a ray diagram to justify your answer. *(CBSE 2017)*

Sol. Given, magnification $(m) = -1$

and $v = +25$ cm (real image as m is negative)

Also, $m = \frac{v}{u}$

$\Rightarrow \quad -1 = \frac{25}{u} \Rightarrow u = -25\,\text{cm}$

Using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

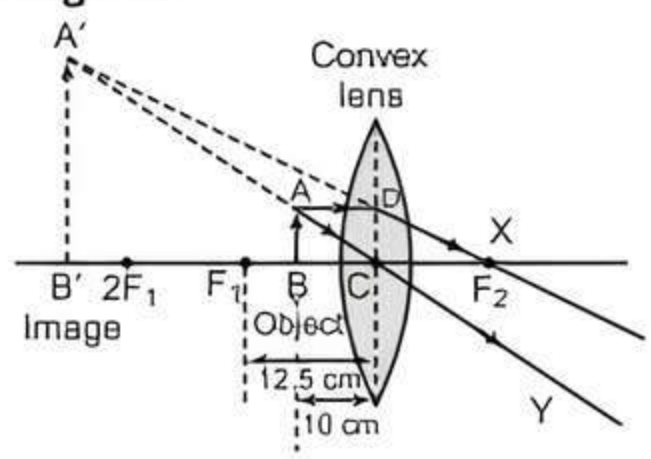
$$= \frac{1}{25} - \left(\frac{1}{-25}\right) = \frac{1+1}{25}$$

$$= \frac{25}{2} = 12.5\ \text{cm}$$

The given lens is a convex lens as its focal length is positive.

On moving the object to a distance of 15 cm towards the lens, the object distance becomes 10 cm (25 − 15) from the optical centre of the lens, *i.e.*, object is now placed between optical centre and focus of the lens. The image formed is virtual and on the same side of the lens as object.

Ray Diagram:



Q 16. (i) A lens of focal length 5 cm is being used by Debashree in the laboratory as a magnifying glass. Her least distance of distinct vision is 25 cm.

(a) What is the magnification obtained by using the glass?

(b) She keeps a book at a distance 10 cm from her eyes and tries to read. She is unable to read. What is the reason for this?

(ii) Ravi kept a book at a distance of 10 cm from the eyes of his friend Hari. Hari is not able to read anything written in the book. Give reason for this. *(CBSE SQP 2022-23)*

Sol. (i) (a) Given, image distance $v = -25$ cm, focal length, $f = 5$ cm, magnification $m = ?$

From lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

or $$\frac{1}{u} = \frac{1}{v} - \frac{1}{f}$$

$$\Rightarrow \quad \frac{1}{u} = \frac{1}{-25} - \frac{1}{5} = \frac{-1-5}{25} = \frac{-6}{25}$$

or object distance $u = \frac{-25}{6}$ cm

COMMON ERR(!)R

Sometimes students forget to write 'unit' in answer that leads to deduction in marks.

We know that, $m = \frac{v}{u} = \frac{-25\times6}{-25} = 6.$

(b) This is because her least distance of distinct vision is 25 cm.

(ii) This is because the least distance of distinct vision is 25 cm.

Q 17. An object of height 10 cm is placed 25 cm away from the optical centre of a converging lens of focal length 15 cm. Calculate the image-distance and height of the image formed. *(CBSE 2023)*

Sol.

TiP

Students should learn the correct sign convention and lens formula.

Given, $h_o = 10$ cm, $f = +15$ cm (convex lens), $u = -25$ cm

Using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{15} + \left(\frac{1}{-25}\right)$$

$$= \frac{5-3}{75} = \frac{2}{75}$$

$$\Rightarrow \quad v = \frac{75}{2} = 37.5 \text{ cm}$$

Therefore, image is formed at a distance of 37.5 cm from the lens.

We know that

$$m = \frac{v}{u} = \frac{h_I}{h_o}$$

$$\Rightarrow \quad \frac{37.5}{-25} = \frac{h_I}{10}$$

$$\Rightarrow \quad h_I = \frac{375}{25} = 15$$

Therefore, height of image formed is 15 cm.

Q 18. Rohit focused the image of a candle flame on a white screen using a convex lens. He noted down the position of the candle, screen and lens as under:

Position of candle = 26.0 cm

Position of convex lens = 50.0 cm

Position of screen = 74.0 cm

(i) What is the focal length of the convex lens?

(ii) Where will the image be formed if he shifts the candle towards the lens at a position of 38 cm?

(iii) Draw a ray diagram to show the formation of the image in case (ii) as said above.

Sol. (i) $u = 50 - 26 = 24$ cm.

$v = 74 - 50 = 24$ cm

Since, $u = v$, this means that the object is placed at $2F_1$

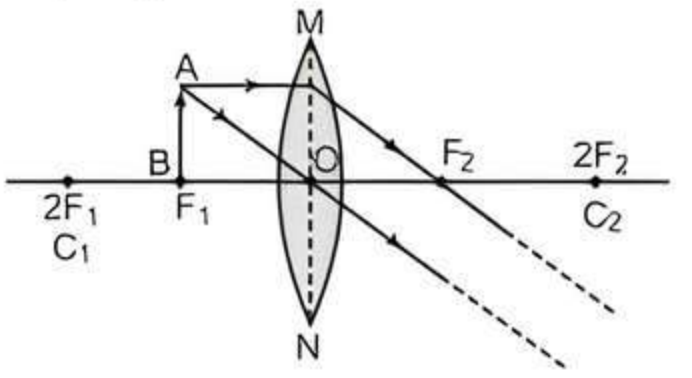
$$\Rightarrow \quad 2f = 24 \text{ cm}$$

$$\Rightarrow \quad f = 12 \text{ cm}$$

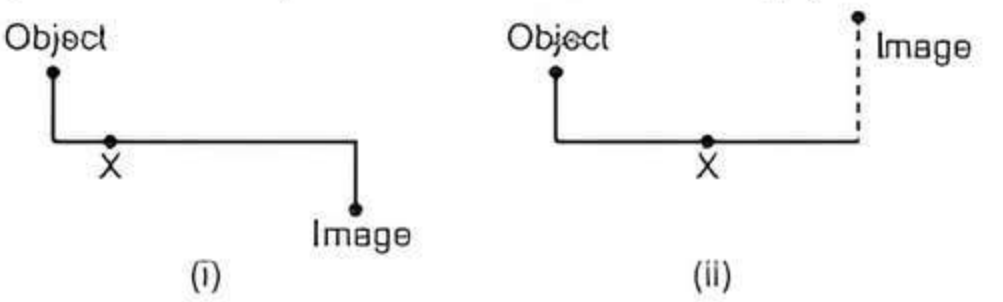
(ii) $u = 50 - 38 = 12$ cm

This implies that the object (candle) is placed at F_1, which means that the image is formed at infinity.

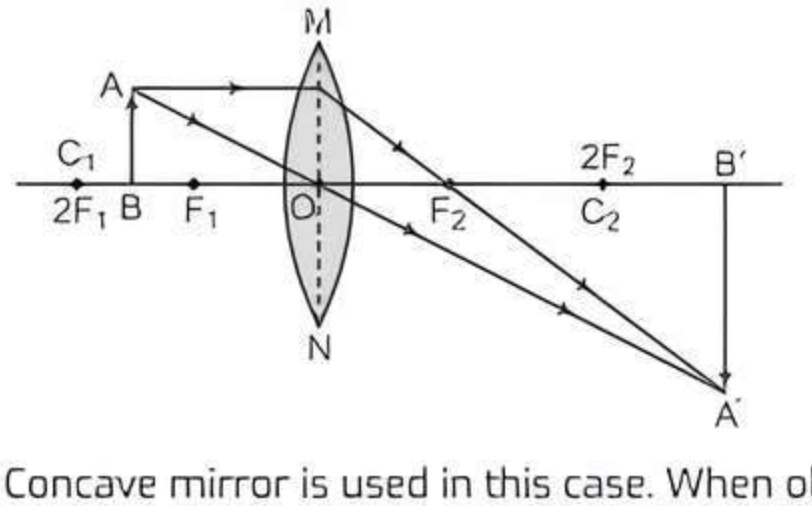
(iii) Ray diagram:



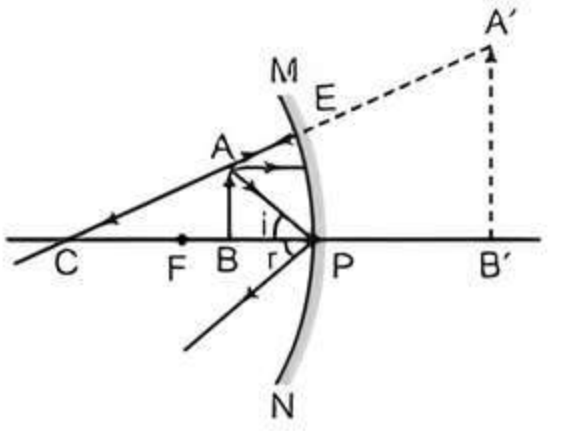
Q 19. The nature, size and position of image of an object produced by a lens or mirror are as shown below. Identify the lens/mirror (*X*) used in each case and draw the corresponding complete ray diagram, (size of the object about half of the image).



Ans. (i) Convex lens is used in this case. When object is placed between F_1 and $2F_1$, its magnified, real and inverted image is formed.



(ii) Concave mirror is used in this case. When object is placed between P and F, its enlarged, erected and virtual image is formed.



Q 20. Define power of a lens. The focal length of a lens is – 10 cm. Write the nature of the lens and find its power. If an object is placed at a distance of 20 cm from the optical centre of this lens, according to the New Cartesian Sign Convention, what will be the sign of magnification in this case? *(CBSE 2023)*

Ans. The ability of a lens to converge or diverge light rays after refraction, is known as power of the lens.

The lens is concave in nature because power of a concave lens is negative.

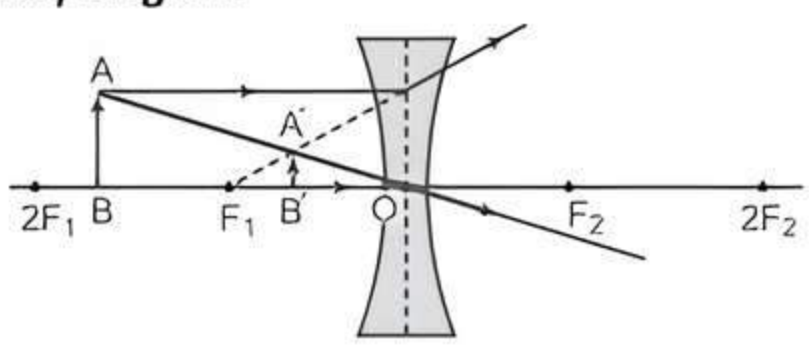
$$\text{Power} = \frac{100}{f} = \frac{100}{-10} = -10 \text{ D}$$

A concave lens forms virtual images for all positions of the object, so magnification produced by a concave lens is always positive.

Q 21. If the image formed by a lens for all positions of an object placed in front of it is always erect and diminished, what is the nature of this lens? Draw a ray diagram to justify your answer. If the numerical value of the power of this lens is 10 D, what is its focal length in the Cartesian system? *(CBSE 2017)*

Ans. A concave lens always gives an erect and diminished image irrespective of the position of the object.

Ray Diagram:



Given. $P = -10$ D (power of concave lens is negative)

Also. $P = \frac{1}{f}$

$\Rightarrow$ $f = \frac{1}{P} = \frac{1}{-10} = -0.1$ m

$\therefore$ Focal length $= -0.1$ m or -10 cm

COMMON ERROR

Generally, students get confused between sign convention for concave and convex lens.

Q 22. The power of a lens is + 4D. Find the focal length of this lens. An object is placed at a distance of 50 cm from the optical centre of this lens. State the nature and magnification of the image formed by the lens and also draw a ray diagram to justify your answer.

Sol. We know that $P = \frac{100}{f \text{ (in cm)}}$

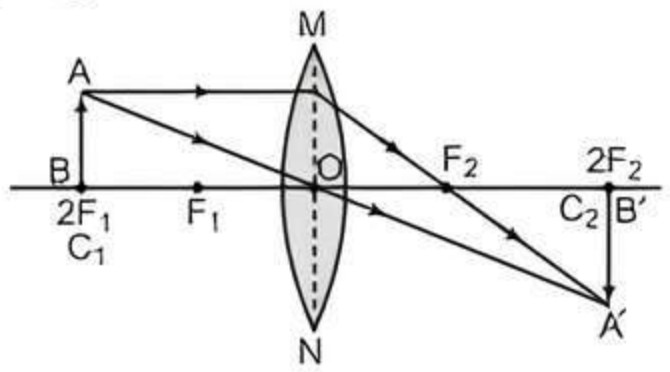
$\therefore$ $f = \frac{100}{P} = \frac{100}{+4} = +25$ cm (convex lens)

Given. $u = -50$ cm. *i.e.*, object is placed at $2F_1$.

Nature of image : Real, Inverted and of same size.

Magnification: -1.

Ray Diagram:



Long Answer Type Questions

Q 1. (i) List four characteristics of the images formed by plane mirrors.

(ii) A 5 cm tall object is placed at a distance of 20 cm from a concave mirror of focal length 30 cm. Use mirror formula to determine the position and size of the image formed. *(CBSE 2019)*

Ans. (i) Characteristics of Image formed by plane mirrors are:

(a) virtual and erect.

(b) laterally inverted.

(c) of the same size as the object.

(d) as far behind the mirror as the object is in front of it.

(ii) Given that.

$h = 5$ cm. $u = -20$ cm. $f = -30$ cm.

Using mirror formula,

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\frac{1}{v} = \frac{1}{-30} - \frac{1}{-20}$$

$$= \frac{-1}{30} + \frac{1}{20} = \frac{-2+3}{60}$$

$v = 60$ cm

We know that.

$$\frac{h'}{h} = \frac{-v}{u} = -60/-20$$

$h' = 3 \times h = 3 \times 5$

$h' = 15$ cm

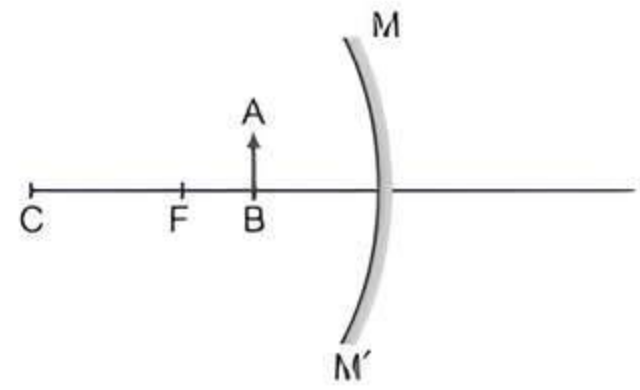
Q 2. (i) Define the following terms in the context of spherical mirrors:

(a) Pole **(b) Centre of curvature**

(c) Radius of curvature **(d) Principal axis**

(ii) Draw ray diagram to show the principal focus of: (a) a concave mirror, and (b) a convex mirror.

(iii) In the following diagram, MM′ is a concave mirror and AB is an object. Draw on your answer sheet a ray diagram to show the formation of image of this object. *(CBSE 2017)*



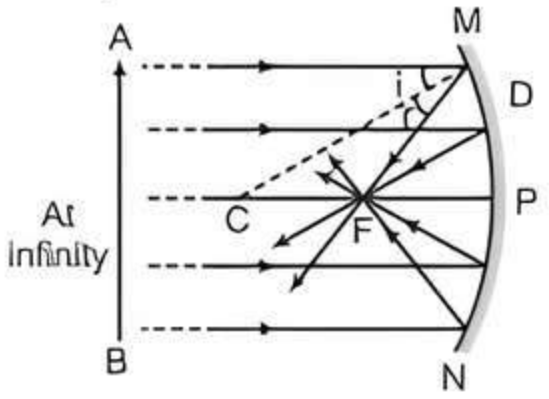
Ans. (i) **(a) Pole:** The centre of the reflecting surface of a spherical mirror is a point called the pole.

(b) Centre of Curvature: It is the centre of the sphere of which mirror forms a part.

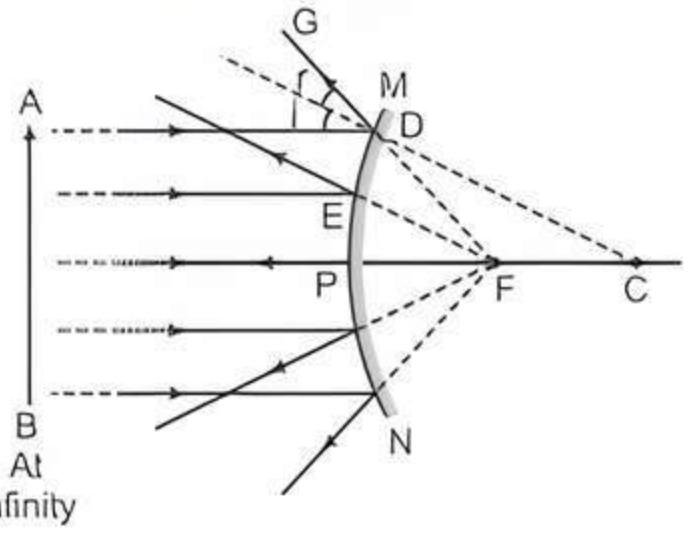
(c) Radius of Curvature: It is the radius of the sphere of which the reflecting surface of a spherical mirror forms a part.

(d) Principal Axis: It is an imaginary straight line passing through the pole and centre of curvature of a spherical mirror.

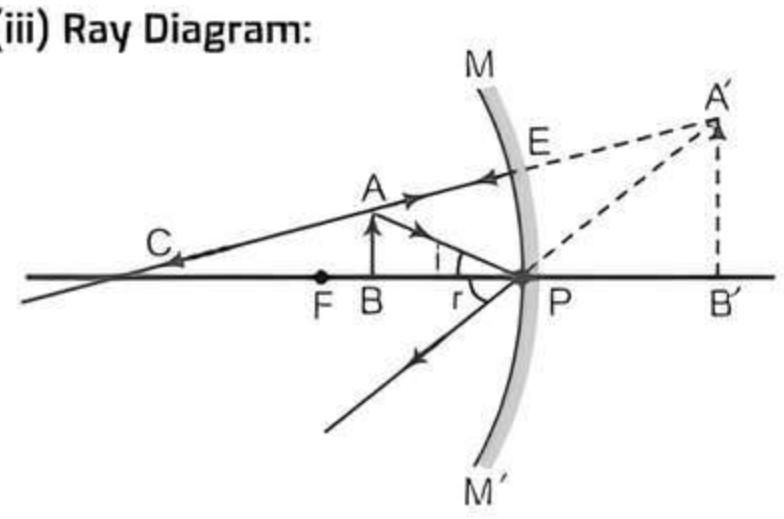
(ii) (a) Principal focus of concave mirror:



(b) Principal focus of convex mirror:



(iii) Ray Diagram:



Q 3. A 10 cm long pencil is placed 5 cm in front of a concave mirror having a radius of curvature of 40 cm.

(i) Determine the position of the image formed by this mirror.

(ii) What is the size of the image?

(iii) Draw a ray diagram to show the formation of the image as mentioned in the part (i).

(CBSE SQP 2023-24)

Sol. (i) Given, $h_o = +10$ cm, $u = -5$ cm, $R = 40$ cm

$$f = \frac{-40}{2} \text{ cm (concave mirror)} = -20 \text{ cm}$$

Using mirror formula,

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{(-20)} - \frac{1}{(-5)}$$

$$= \frac{-1}{20} + \frac{1}{5} = \frac{-1+4}{20} = \frac{3}{20}$$

$$\Rightarrow \quad v = \frac{20}{3} = 6.67 \text{ cm}$$

The image is formed 6.67 cm behind the mirror.

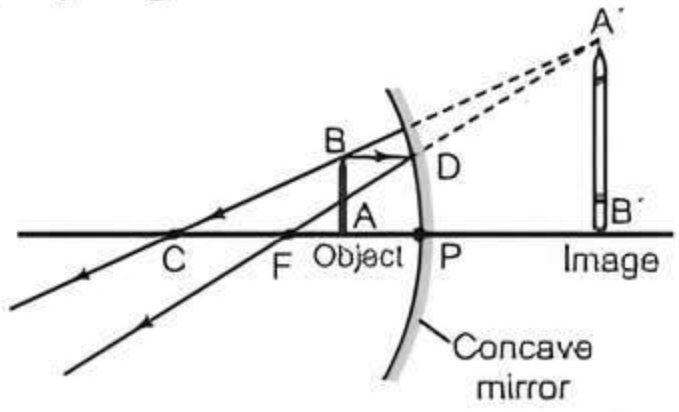
(ii) We know that, $m = \frac{-v}{u} = \frac{h_i}{h_o}$

$$\Rightarrow \quad h_i = \frac{-v}{u} \times h_o$$

$$= \frac{-6.67}{-5} \times 10$$

$$= 13.34 \text{ cm}$$

(iii) Ray Diagram:



Q 4. Suppose you have three concave mirrors, A, B and C of focal lengths 10 cm, 15 cm and 20 cm. For each concave mirror, you perform the experiment of image formation for three values of object distances of 10 cm, 20 cm and 30 cm. Giving reason, answer the following:

(i) For the three object distances, identify the mirror/mirrors which will form an image of magnification –1.

(ii) Out of the three mirrors, identify the mirror which would be preferred to be used for shaving purposes/make up.

(iii) For the mirror B, draw ray diagram for image formation for object distances 10 cm and 20 cm.

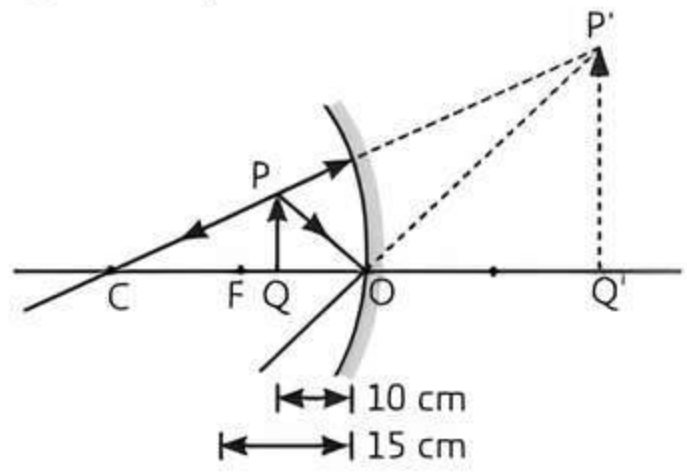
(CBSE 2016)

Ans. (i) A real, inverted and same size image of the object is formed by the concave mirror of magnification –1. It is possible when the object is placed at C (R = 2f). Therefore, for the object distances of 20 cm and 30 cm, the concave mirrors 'A' and 'B' will produce the real, inverted and same size image of the object. So, the concave mirrors 'A' and 'B' will form an image of magnification –1.

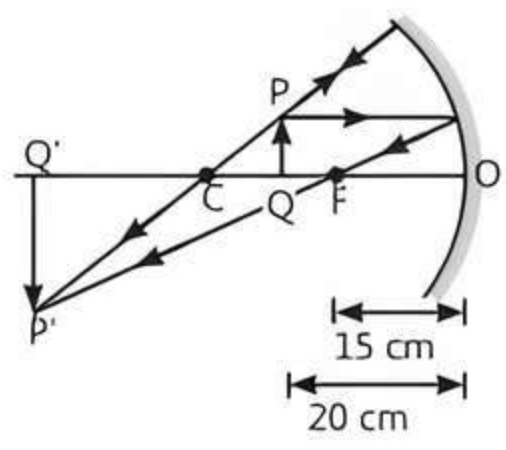
(ii) The concave mirror 'C' of focal length 20 cm must be preferably used for shaving purposes. The reason is, when we bring our face within its focal length, it forms a virtual, erect and enlarged image of our face.

(iii) Ray diagram for image formation by mirror B:

(a) For object distance 10 cm.



(b) For object distance 20 cm.



Q 5. (i) A security mirror used in a big showroom has radius of curvature 5 m. If a customer is standing at a distance of 20 m from the cash counter, find the position, nature and size of the image formed in the security mirror.

(ii) Neha visited a dentist in his clinic. She observed that the dentist was holding an instrument fitted with a mirror. State the nature of this mirror and reason for its use in the instrument used by dentist.

Ans.

TiP

The given mirror is convex because convex mirrors are used as security mirrors in big showrooms.

(i) $R = 5$ m

$f = \frac{+5}{2}$m (Convex mirror) $u = -20$ m

According to mirror formula.

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} + \frac{1}{-20} = \frac{1}{5/2}$$

$$\frac{1}{v} - \frac{1}{20} = \frac{2}{5}$$

$$\frac{1}{v} = \frac{2}{5} + \frac{1}{20} = \frac{8+1}{20} = \frac{9}{20}$$

$$v = \frac{20}{9} = 2.2\text{m}$$

Let h_1 be x

$$m = \frac{-v}{u} = \frac{h_2}{x}$$

$$\Rightarrow \quad \frac{-20}{9x - 20} = \frac{h_2}{x}$$

$$\frac{1}{9} = \frac{h_2}{x}$$

$$h_2 = \frac{x}{9}$$

Virtual and erect image is formed.

Size: Image would be $\frac{1}{9}$th of the original size of the customer *i.e.*, diminished image.

(ii) This mirror will be concave mirror because it forms virtual erect and enlarged image of the object (when object is placed between pole and focus of this mirror). It helps the doctor to see an enlarged image of tooth.

Q 6. (i) On entering in a medium from air, the speed of light becomes half of its value in air. Find the refractive index of that medium with respect to air.

(ii) A glass slab made of a material of refractive index n_1 is kept in a medium of refractive index n_2. A light ray is incident on the slab. Draw the path of the rays of light emerging from the glass slab, if (a) $n_1 > n_2$ (b) $n_1 = n_2$ (c) $n_1 < n_2$.

Ans. (i) We know that.

Refractive index of a medium (μ) = Velocity of light in vacuum / Velocity of light in the medium.

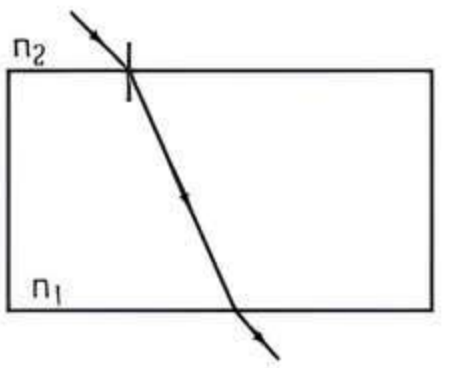
Let the velocity of light in vacuum be v_1 and velocity of light in the medium be v_2.

Hence, $\mu = v_1/v_2$

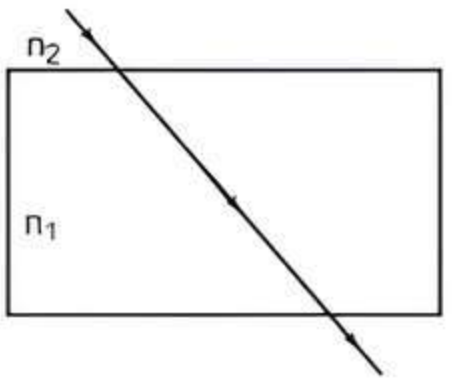
$= v_1/(v_1/2)$ [Given that, $v_2 = v_1/2$]

$= 2$

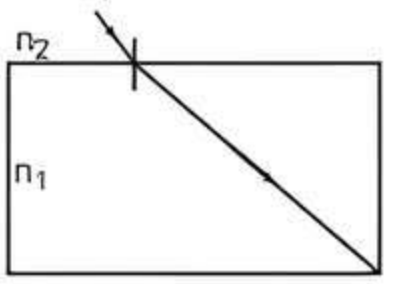
(ii) (a) The ray moves towards the normal.



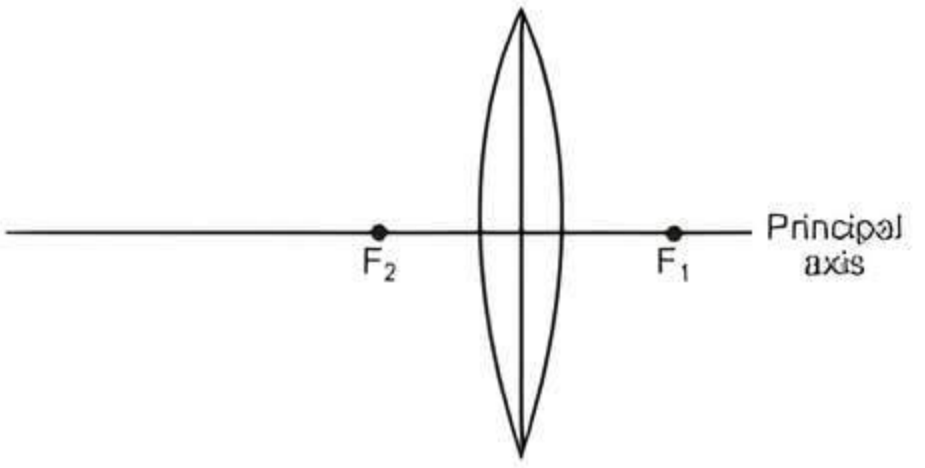
(b) The ray moves undeviated.



(c) The ray moves away from the normal.



Q 7.



The above image shows a thin lens of focal length 5 m.

(i) What is the kind of lens shown in the above figure?

(ii) If a real inverted image is to be formed by this lens at a distance of 7 m from the pole, then show with calculation where should the object be placed?

(iii) Draw a neatly labelled diagram of the image formation mentioned in (ii). *(CBSE SQP 2023-24)*

Ans. (i) Convex lens

(ii) Given, $f = +5$ m (convex lens)

$v = +7$ m (real image)

Using lens formula,

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$$

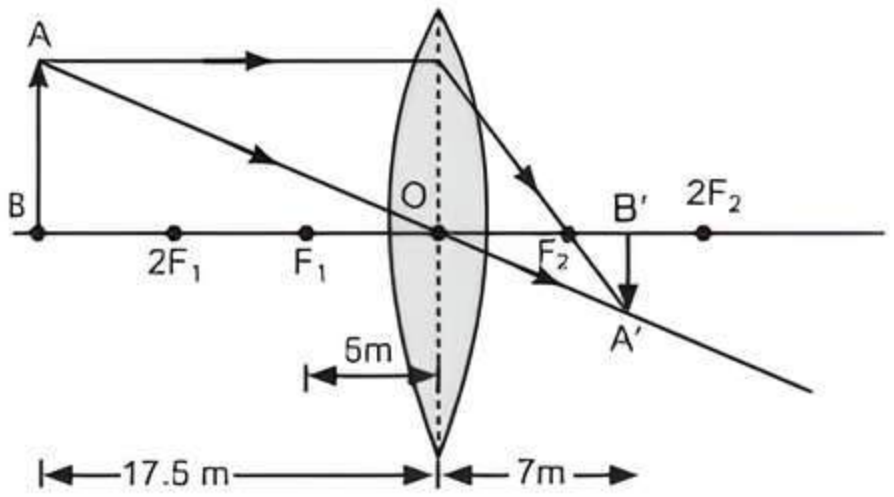
$$\Rightarrow \quad \frac{1}{u}=\frac{1}{v}-\frac{1}{f}=\frac{1}{7}-\frac{1}{5}$$

$$=\frac{5-7}{35}=\frac{-2}{35}$$

$$\Rightarrow \quad u=\frac{-35}{2}=-17.5 \text{ cm}$$

Thus, the object should be placed at a distance of 17.5 m in front of the convex lens. The minus sign shows that the object is on the left side of the lens.

(iii) **Ray Diagram:**



Q 8. Rishi went to a palmist to show his plan. The palmist used a special lens for this purpose.

(i) State the nature of the lens and reason for its use.

(ii) Where should the palmist place/hold the lens so as to have a real and magnified image of an object?

(iii) If the focal length of this lens is 10 cm and the lens is held at a distance of 5 cm from the palm, use lens formula to find the position and size of the image. *(CBSE 2020)*

Ans. (i) The lens is convex because it forms virtual, erect and magnified image of his palm.

(ii) Real and magnified image is obtained when the object is placed between f and $2f$ of the lens.

(iii) Given : $f = +10$ cm

$u = -5$ m

$v = ?$

According to lens formula,

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{v}-\frac{1}{-5}=\frac{1}{10}$$

$$\frac{1}{v}+\frac{1}{5}=\frac{1}{10}$$

$$\frac{1}{v}=\frac{1}{10}-\frac{1}{5}$$

$$\frac{1}{v}=\frac{1-2}{10}=\frac{-1}{10}$$

$$v = -10 \text{ cm}$$

Image will be formed at a distance of 10 cm on the left hand side of lens.

$$m=\frac{h_2}{h_1}=\frac{v}{u}$$

Let h_1 be x.

$$\therefore \quad \frac{h_2}{x}=\frac{-10}{-5}$$

$$h_2 = 2x$$

So, the size of the image will be twice of the object.

Q 9. Analyse the following observation table showing variation of image-distance (v) with object-distance (u) in case of a convex lens and answer the questions that follow without doing any calculations:

S.No.	Object-Distance u (cm)	Image-Distance v (cm)
1	– 100	+ 25
2	– 60	+ 30
3	– 40	+ 40
4	– 30	+ 60
5	– 25	+ 100
6	– 15	+ 120

(i) What is the focal length of the convex lens? Give reason to justify your answer.

(ii) Write the serial number of the observation which is not correct. On what basis have you arrived at this conclusion?

(iii) Select an appropriate scale and draw a ray diagram for the observation at S.No.2. Also find the approximate value of magnification.

Ans. (i) From S.No. 3, we can say that the radius of curvature of the lens is 40 cm because when the object is placed at centre of curvature of a convex lens, its image is formed on the other side of the lens at the same distance from the lens.

$$\therefore \quad R = 40 \text{ cm}$$

$$\Rightarrow \quad f=\frac{R}{2}=\frac{40}{2}=20 \text{ cm}$$

(ii) S.No. 6 is not correct as the object is between focus and optical centre.

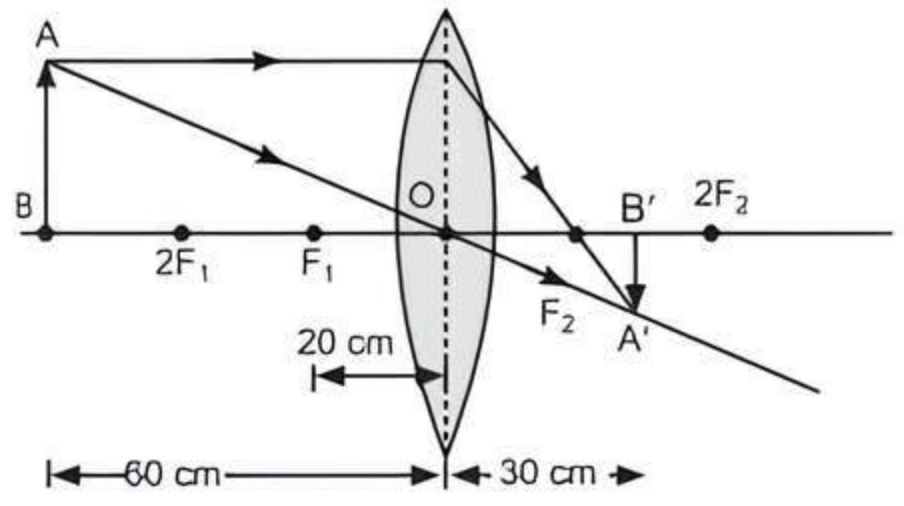
Thus, image formed will be on the same side of the lens as the object, *i.e.*, 'V must be negative.

But in S.No. 6, v is positive so S.No.6 is incorrect.

TiP

Be clear with concepts of nature, position and size of the image formed by a convex lens. Also, practice image formation in lenses using ray diagrams.

(III) **Ray Diagram for S.No. 2:**



Magnification, $m = \frac{v}{u} = \frac{+30}{-60} = -0.5$

COMMON ERROR

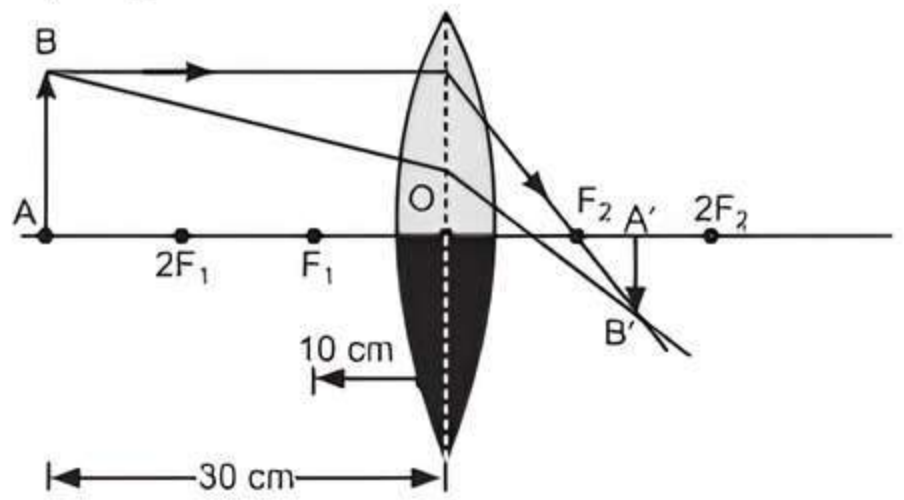
Generally students forget to find the value of magnification in this question.

Q 10. One-half of a convex lens of focal length 10 cm is covered with a black paper. Can such a lens produce an image of a complete object placed at a distance of 30 cm from the lens? Draw a ray diagram to justify your answer.

A 4 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. *(CBSE 2015)*

Ans. Yes, a complete image of an object will be produced with less intensity. This is because the light falling on the covered portion will not reach the image position.

Ray Diagram:



Given, for a convex lens, $h_o = +4$ cm.

$f = +20$ cm.

$u = -15$ cm

By using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{20} = \frac{1}{v} - \frac{1}{-15} = \frac{1}{v} + \frac{1}{15}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{1}{20} - \frac{1}{15} = \frac{3-4}{60} = -\frac{1}{60}$$

$$\Rightarrow \quad v = -60 \text{ cm}$$

Hence, the image is formed on the same side of the object at a distance of 60 cm from the optical centre of the lens. The negative sign indicates that image is virtual.

Now, $$m = \frac{h_I}{h_o} = \frac{v}{u}$$

$$\Rightarrow \quad h_I = \frac{v}{u} \times h_o = \frac{-60}{-15} \times 4 = +16 \text{ cm}$$

Hence, the image is four times larger than the size of the object, *i.e.*, 16 cm. The positive sign indicates that image is erect.

Q 11. (i) Define optical centre of a spherical lens.

(ii) A divergent lens has a focal length of 20 cm. At what distance should an object of height 4 cm from the optical centre of the lens be placed so that its image is formed 10 cm away from the lens. Find the size of the image also.

(iii) Draw a ray diagram to show the formation of image in above situation. *(CBSE 2016)*

Ans. (i) **Optical Centre:** It is the central point 'O' on the principal axis of the lens, through which an incident ray of light passes (refracted) without suffering any deviation.

(II) Given, $f = -20$ cm, $h_o = 4$ cm, $v = -10$ cm

By using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \quad \frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{-10} - \frac{1}{-20}$$

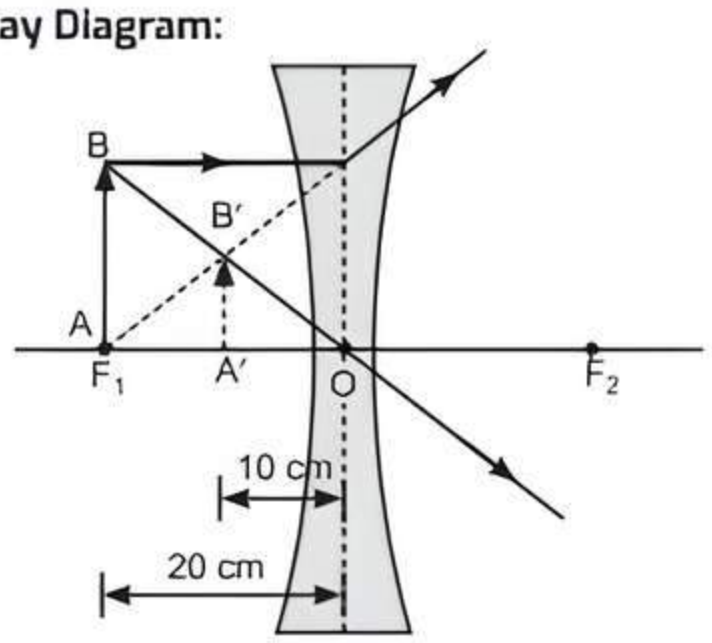
$$\Rightarrow \quad u = -20 \text{ cm}$$

Now, $$m = \frac{h_I}{h_o} = \frac{v}{u}$$

$$\Rightarrow \quad h_I = \frac{v}{u} \times h_o = \frac{-10}{-20} \times 4 = +2$$

Hence, a diminished virtual image is formed and its size is 2 cm.

(III) **Ray Diagram:**



Q 12. An object is placed at a distance of 30 cm from a concave lens of focal length 30 cm.

(i) Use lens formula to determine the distance of the image from the lens.

(ii) List four characteristics of the image (nature, position, size, erect/inverted) in this case.

(iii) Draw a labelled diagram to justify your answer of part (ii). *(CBSE 2019)*

Sol. (i) Given: $u = -30$ cm, $f = -30$ cm

Using lens formula, $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\Rightarrow$ $\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$

$= \frac{1}{(-30)} + \frac{1}{(-30)} = \frac{-1-1}{30}$

$\frac{1}{v} = \frac{-2}{30} = \frac{-1}{15}$

$v = -15$ cm

Now, $m = \frac{v}{u}$

$\Rightarrow$ $m = \frac{-15\text{ cm}}{-30\text{ cm}} = +\frac{1}{2}$

(ii) Characteristics of the image:

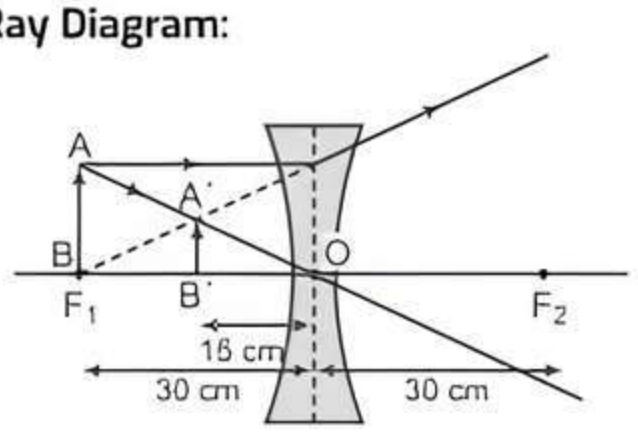
(a) Nature: Virtual

(b) Position: 15 cm from the lens on the same side as the object.

(c) Size of the image: Diminished

(d) Image formed: Erect

(iii) Ray Diagram:



Chapter Test

Multiple Choice Questions

Q 1. An object is placed 20 cm in front of a plane mirror. The mirror is moved 2 cm towards the object. The distance between the positions of the original and final images seen in the mirror is:

a. 2 cm b. 4 cm c. 10 cm d. 22 cm

Q 2. No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be:

a. only plane b. only concave

c. only convex d. either plane or convex

Q 3. Rays from Sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object? *(NCERT EXEMPLAR)*

a. 15 cm in front of the mirror

b. 30 cm in front of the mirror

c. Between 15 cm and 30 cm in front of the mirror

d. More than 30 cm in front of the mirror

Q 4. The angle of incidence for a ray of light having zero reflection angle is:

a. 0° b. 30° c. 45° d. 90°

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.

d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): A convex mirror is used as a driver's mirror.

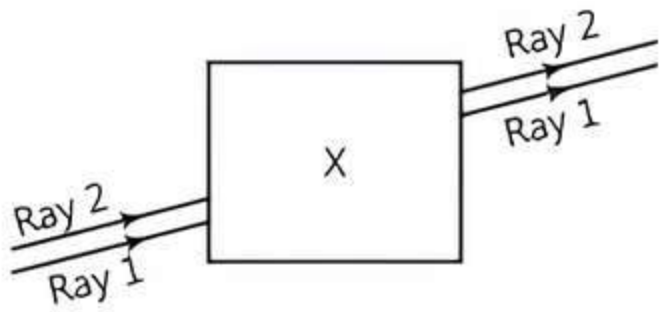
Reason (R): Because convex mirror's field of view is large and images formed are virtual, erect and diminished.

Q 6. Assertion (A): Property of converging a convergent lens does not remain same in all media.

Reason (R): Property of lens whether the ray is diverging or converging is independent of the surrounding medium.

Case Study Based Question

Q 7. Noor, a young student, was trying to demonstrate some properties of light in her science project work. She kept 'X' inside the box (as shown in the figure) and with the help of a laser pointer made light rays pass through the holes on one side of the box. She had a small butter-paper screen to see the spots of light being cast as they emerged.



Read the above passage carefully and give the answer of the following questions:

(i) What could be the 'X' that she placed inside the box to make the rays behave as shown?

a. a converging lens

b. a parallel-sided glass block

c. a plane mirror

d. a triangular prism

(ii) She measured the angles of incidence for both the rays on the left side of the box to be 48.6°. She knew the refractive index of the material '*X*' inside the box was 1.5. What will be the approximate value of angle of refraction?
(Use the value sin 48.6° ≈ 0.75)

a. 45° b. 40° c. 30° d. 60°

(iii) Her friend noted the following observations from this demonstration:

I. Glass is optically rarer than air.
II. Air and glass allow light to pass through them with the same velocity.
III. Air is optically rarer than glass.
IV. Speed of light through a denser medium is faster than that of a rarer medium.
V. The ratio: sin of angle of incidence in the first medium to the ratio of sin of angle of refraction in the second medium, gives the refractive index of the second material with respect to the first one.

Which one of the combination of the above statements given below is correct?

a. (II). (IV) and (V) are correct.
b. (III) and (IV) are correct.
c. (I). (IV) and (V) are correct.
d. (III) and (V) are correct.

(iv) If the object inside the box was made of a material with a refractive index less than 1.5 then the:

a. lateral shift of the rays would have been less.
b. lateral shift of the rays would have been more.
c. lateral shift of the rays would remain the same as before.
d. there is not enough information to comment on any of the above statements.

Very Short Answer Type Questions

Q 8. What is the nature of the mirror having focal length −15 cm?

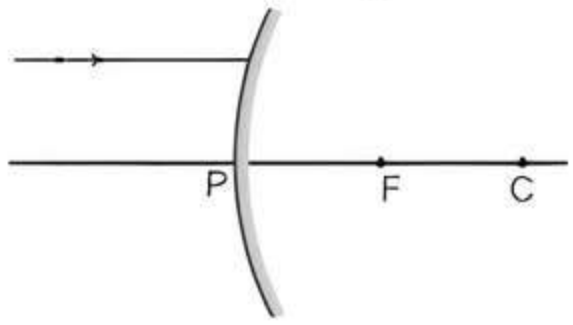
Q 9. What is the name given to the change in path of light with the change of medium?

Short Answer Type-I Questions

Q 10. The linear magnification produced by a spherical is $-\frac{1}{5}$. Analysing this value, state the (I) type of spherical mirror and (ii) the position of the object with respect to the pole of the mirror. Draw ray diagram to justify your answer.

Q 11. A concave mirror of focal length f can form a magnified erect as well as an inverted image of an object placed in front of it. Justify this statement stating the position of the object with respect to the mirror in each case for obtaining these image.

Q 12. A ray of light is incident on a convex mirror as shown. Redraw the diagram and complete the path of this ray after reflection from the mirror. Make angle of incidence and angle of reflection on it.



Short Answer Type-II Questions

Q 13. A convex lens made of a material of refractive index n_2 is kept in a medium of refractive index n_1. A parallel beam of light in incident on the lens. Draw the path of rays of light emerging from the convex lens, if:
(i) $n_1 < n_2$ (ii) $n_1 = n_2$
(iii) $n_1 > n_2$

Q 14. Define the following:
(i) focal length (ii) Principal focus
(iii) 1 dioptre

Q 15. Size of image of an object by a mirror having a focal length of 20 cm is observed to be reduced to 1/3rd of its size. At what distance the object has been placed from the mirror? What is the nature of the image and the mirror?

Long Answer Type Questions

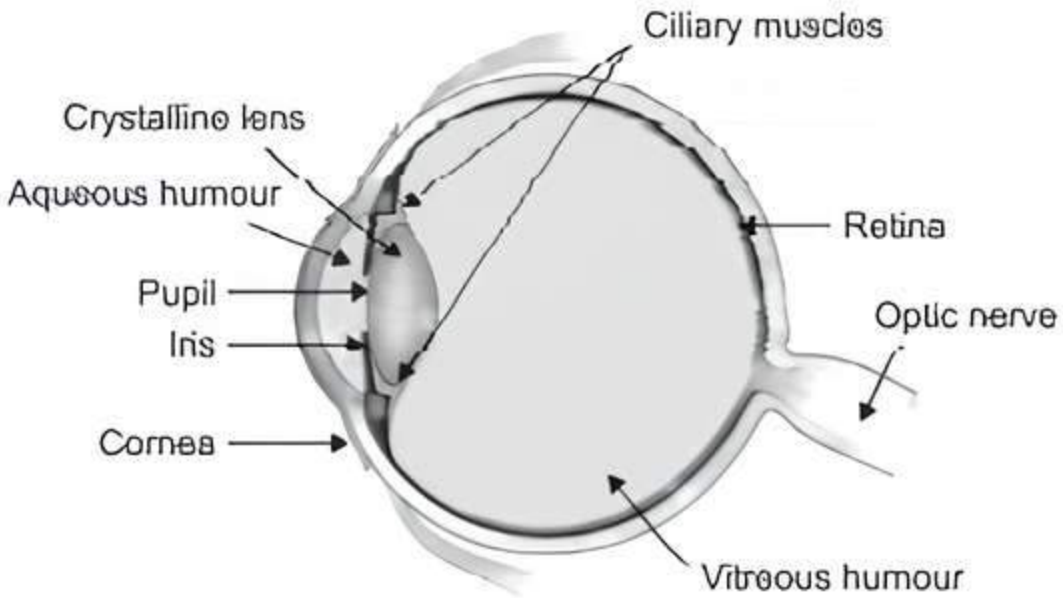
Q 16. A concave mirror and a convex mirror are placed co-axially, their reflecting surfaces facing each other. Their focal lengths are 15 cm and 12 cm respectively. An object placed between them is 20 cm from the concave mirror. The image formed by it is at the object itself. Calculate the distance of the convex mirror from the object.

Q 17. A convex lens can form a magnified erect as well as magnified inverted image of an object placed in front of it. Draw ray diagram to justify this statement stating the position of the object with respect to the lens in each case. An object of height 4 cm is placed at a distance of 20 cm from a concave lens of focal length 10 cm. Use lens formula to determine the position of the image formed.

10 The Human Eye and the Colourful World

Fastrack Revision

- **Human Eye:** It is one of the most valuable and sensitive sense organs. It is an optical device that serves as our organ of sight. Human eye is like a camera and is based on the lens system. It enables us to see the wonderful and colourful world by forming an image on a light-sensitive screen called the retina.



The Human Eye

It consists of the following parts:

(i) **Cornea:** It is a thin membrane through which light enters the eye.

(ii) **Iris:** It is a dark muscular diaphragm that controls the size of the pupil.

(iii) **Pupil:** It regulates and controls the amount of light entering the eye.

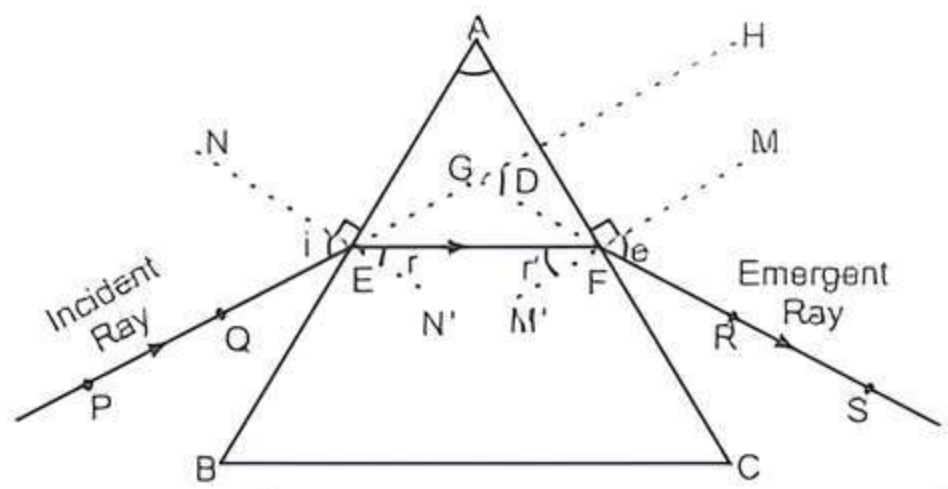
(iv) **Eye Lens:** It is a convex lens made of transparent and fibrous jelly-like material. Its curvature can be adjusted through ciliary muscles. It forms an inverted real image of the object on the retina.

(v) **Retina:** It works as a screen having enormous number of light-sensitive cells. The light-sensitive cells convert light into electrical signals and transmit these signals to the brain through optic nerve for visual recognition.

MNEMONICS

Concept : *Parts of the human eye*
Mnemonics: ***I****nnocent* ***C****ircus* ***P****eople* ***L****ove* ***R****aisin* ***O****ats*
Interpretation: *Iris, Cornea, Pupil, Lens, Retina, Optic Nerve.*

- **Power of Accommodation:** The ability of eye lens to focus the distant objects as well as nearby objects on the retina by changing the focal length of the eye lens is known as power of accommodation of the eye.
- **Far Point of the Eye:** It is the farthest point up to which the eye can see clearly. It is infinity for a normal eye.
- **Near Point of the Eye:** The minimum distance from eye from which an object can be seen most distinctly without any strain is called near point of the eye. For a healthy normal eye of an adult, it is 25 cm.
- **Myopia:** In this defect, a person can see nearby objects clearly, but is unable to see distant objects clearly, since the image of a distant object (at infinity) is formed in front of the retina. Myopia is caused due to excessive curvature of eye lens or elongation of eyeball. This defect can be corrected by using concave lens of suitable focal length.
- **Hypermetropia:** In this defect, a person can see distant objects clearly but unable to see nearby objects distinctly, since the image of normal near point is formed behind the retina. This type of defect is known as hypermetropia or far-sightedness. Hypermetropia is caused due to decrease in power of eye lens (increase in focal length of eye lens) or shortening of eye ball. The defect can be corrected by using convex lens of suitable focal length.
- **Presbyopia:** Due to old age or excessive reading or careless practices of a person, the power of accommodation of the eye decreases. In such a situation, a person cannot see the nearby objects as well as distant objects clearly. Such type of defect is known as presbyopia. Presbyopia is caused due to decrease in flexibility of eye lens and gradual weakening of ciliary muscles. This defect can be corrected by using bi-focal lenses. A bi-focal lens consists of both convex lens (to facilitate near vision) and concave lens (to facilitate distant vision).
- **Prism:** A prism is a transparent material bounded by five plane surfaces (two triangular bases and three rectangular lateral surfaces) inclined at some angles. When a ray of light passes through a glass prism, refraction (or bending) of light occurs twice, once when it enters the prism and then when it leaves the prism. The diagram shows refraction of a ray of light through a prism.

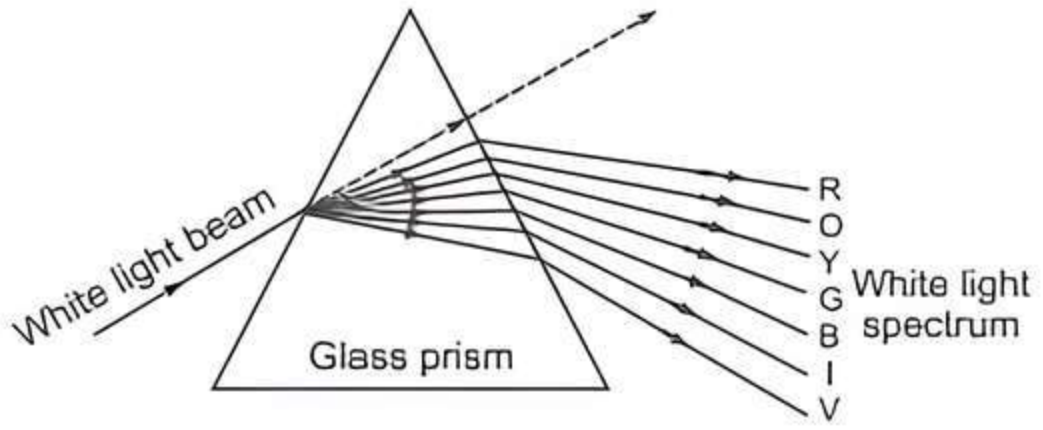


Here, PE = Incident ray, FS = Emergent ray, $\angle i$ = Angle of incidence, $\angle e$ = Angle of emergence, EF = Refracted ray, $\angle A$ = Angle of prism, $\angle r$ = Angle of refraction, $\angle D$ = Angle of deviation.

(i) The angle between incident ray and emergent ray is called angle of deviation.

(ii) In refraction through a glass slab, the emergent ray is parallel to the incident ray, but in refraction through a glass prism, the emergent ray is not parallel to the incident ray.

- **Dispersion:** The splitting of white light into its components due to different bending abilities of colours when it passes through a prism is called dispersion.



Dispersion of White Light by the Glass Prism

- **Recombination of White Light:** Isaac Newton was the first to use a glass prism to obtain the spectrum of sunlight. He found that when an inverted prism is placed in the path of dispersed light then after passing through prism, they recombine to form white light. He observed that the red colour bends the least while the violet colour bends the most.
- **Spectrum:** The rainbow is an arc of seven colours (Violet, Indigo, Blue, Green, Yellow, Orange and Red), visible in the sky due to dispersion of Sun's light by raindrops present in the atmosphere. This arc (called VIBGYOR) is known as spectrum. It is formed due to dispersion, refraction and total internal reflection of light.
- **Atmospheric Refraction:** The refraction of light caused by the Earth's atmosphere (having air layers of varying optical densities) is atmospheric refraction. Twinkling of Stars, the Stars seem higher than they actually are and advanced sunrise and delayed sunset are some phenomenon based on atmospheric refraction.
- **Scattering of Light:** When a ray of light passes through a path of suspended particles, it splits up in various random directions. Such a phenomenon is known as scattering of light. In this situation, scattering depends upon the size of the particles as in the case of a true solution and a colloidal solution. According to Rayleigh's law of scattering, the amount of scattered light is $1/(\text{wavelength})^4$.
- **Tyndall Effect:** The phenomenon of scattering of light by the colloidal particles is known as Tyndall effect.
  (i) The scattering of blue component of the white sunlight by air molecules present in the atmosphere causes the blue colour of the sky.
  (ii) In outer space, the sky looks black instead of blue because there is no atmosphere to scatter sunlight.

Practice Exercise

Multiple Choice Questions

Q 1. The phenomenon of light responsible for the working of the human eye is:
a. refraction
b. reflection
c. power of accommodation
d. persistence of vision

Q 2. Match the parts of eye given in Column (A) with their appropriate function given in Column (B):

Column (A)	Column (B)
A. Pupil	1. It converts images formed by lens into electrical impulses.
B. Retina	2. It controls the size of the pupil.
C. Cornea	3. It controls the amount of light entering the eye.
D. Iris	4. Light enters the eye through it.

	A	B	C	D
a.	2	1	4	3
b.	3	1	4	2
c.	3	4	1	2
d.	2	4	1	3

Q 3. When we enter a dark room coming from outside, the things inside the room do not appear clear to our eyes immediately. This is because:
a. pupils do not open at all in the dark
b. pupils take time to adjust
c. light travels slower in a dark room
d. pupils open very quickly in the dark

Q 4. When light rays enter the eye, most of the refraction occurs at the:
a. crystalline lens
b. outer surface of the cornea
c. iris
d. pupil

Q 5. The image distance from the eye lens in the normal eye when we increase the distance of an object from the eye: *(CBSE 2020)*
a. increases
b. decreases
c. remains unchanged
d. depends on the size of the eyeball

Q 6. A person cannot see objects distinctly kept beyond 2 m. This defect can be corrected by using which type of lens and of what power?
a. Convex lens, + 0.5 D
b. Concave lens, + 0.5 D
c. Convex lens, – 0.2D
d. Concave lens, – 0.5 D

Q 7. Which of the following is considered as a reason for hypermetropia?
a. The eye lens is not able to contract
b. The eye lens becomes thick
c. The eye lens becomes thin
d. Both a. and b.

Q 8. What is the cause of presbyopia?
a. Weakening of ciliary muscles
b. Thin eye lens
c. Both a. and b.
d. Thickness of eye lens

Q 9. Person suffering from cataract has: *(CBSE 2020)*

a. elongated eyeball
b. excessive curvature of eye lens
c. weakened ciliary muscles
d. opaque eye lens

Q 10. When a ray passes through a prism:

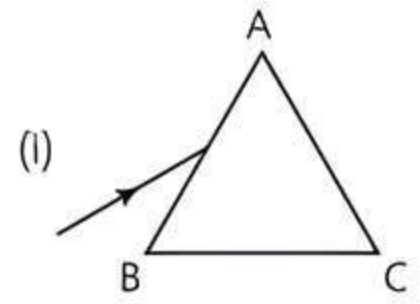
a. it goes undeviated
b. it remains parallel to the base
c. it bends towards the base
d. None of the above

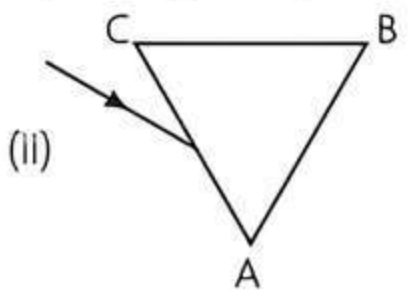
Q 11. A transparent refracting material which is bounded by two plane refracting surfaces is:

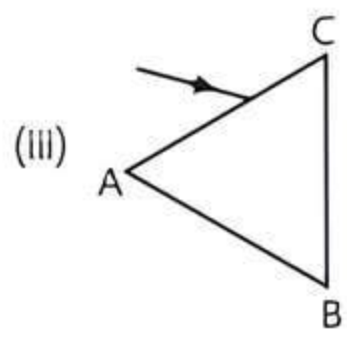
a. prism
b. convex lens
c. glass slab
d. None of these

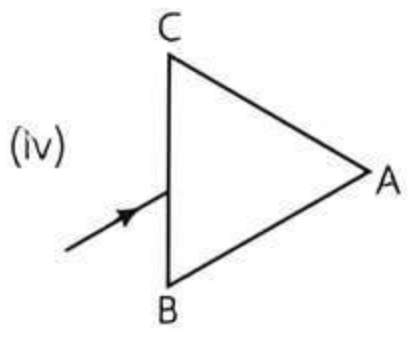
Q 12. A prism ABC (with BC as base) is placed in different orientations. A narrow beam of white light is incident on the prism as shown in below figure. In which of the following diagrams, after dispersion, the third colour from the top of the spectrum corresponds to the colour of the sky?

(CBSE SQP 2021, Term-1)







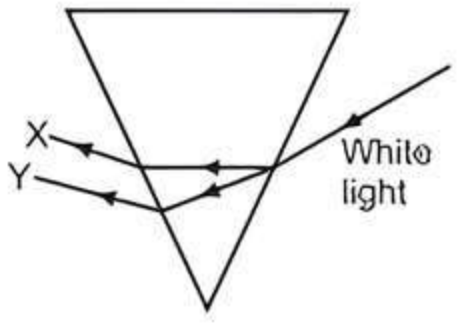


a. (I)
b. (II)
c. (iii)
d. (iv)

Q 13. If a beam of red light and a beam of violet light are incident at the same angle on the inclined surface of a prism from air medium and produce angles of refraction *r* and *v* respectively, which of the following is correct? *(CBSE SQP 2021, Term-1)*

a. $r = v$
b. $r > v$
c. $r = 1/v$
d. $r < v$

Q 14. In the diagram given below, *X* and *Y* are the end colours of the spectrum of white light. The colour of '*Y*' represents the:



a. Colour of sky as seen from Earth during the day
b. Colour of the sky as seen from the Moon
c. Colour used to paint the danger signals
d. Colour of Sun at the time of noon

Q 15. Which of the following phenomenon of light are involved in the formation of a rainbow? *(NCERT EXEMPLAR)*

a. Reflection, refraction and dispersion
b. Refraction, dispersion and total internal reflection
c. Refraction, dispersion and internal reflection
d. Dispersion, scattering and total internal reflection

Q 16. The sky appears dark to passengers flying at very high altitudes mainly because: *(CBSE 2020)*

a. scattering of light is not enough at such heights
b. there is no atmosphere at great heights
c. the size of molecules is smaller than the wavelength of visible light
d. the light gets scattered towards the Earth

Q 17. Twinkling of stars is due to atmospheric: *(NCERT EXEMPLAR)*

a. dispersion of light by water droplets
b. refraction of light by different layers of varying refractive indices
c. scattering of light by dust particles
d. internal reflection of light by clouds

Q 18. When light enters the atmosphere, it strikes on extremely fine particles, which deflect the rays of light in all possible directions. This is due to: *(CBSE SQP 2023-24)*

a. reflection of light
b. atmospheric refraction
c. scattering of light
d. dispersion of light

Q 19. Which of the following is not the cause of atmospheric refraction?

a. Apparent image of Sun is formed closer to the Earth
b. Dawn or dusk are formed
c. Sun can be seen 2 minutes before actual sunrise and 2 minutes after actual sunset
d. Clouds look white

Q 20. Refraction of light by the Earth's atmosphere due to variation in air density is called:

a. atmospheric reflection
b. atmospheric dispersion
c. atmospheric scattering
d. atmospheric refraction

Assertion & Reason Type Questions

Directions (Q. Nos. 21-28): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 21. **Assertion (A):** Ciliary muscles help in changing the focal length of the eye lens.
Reason (R): Ciliary muscles help to focus near and distant objects in quick succession.

Q 22. **Assertion (A):** A person suffering from myopia cannot see the distant objects clearly.
Reason (R): A converging lens is used for the correction of myopic eye as it can form real as well as virtual images of the objects placed in front of it. *(CBSE 2023)*

Q 23. **Assertion (A):** The white light is dispersed into seven constituent colours when passed through the prism.
Reason (R): Different colours of light bend through different angles as they pass through a prism.

Q 24. **Assertion (A):** The planets twinkle while the Stars do not.
Reason (R): The planets are much closer to the Earth than the Stars.

Q 25. **Assertion (A):** The rainbow is seen when the Sun is behind the observer.
Reason (R): Rainbow is produced due to dispersion of white light by small rain drops hanging in the air after the rain.

Q 26. **Assertion (A):** The Sun is visible to us about 2 minutes before the actual sunrise and about 2 minutes after the actual sunset because of atmospheric refraction.
Reason (R): The time difference between actual sunset and the apparent sunset is about 4 minutes.

Q 27. **Assertion (A):** The scattering of longer wavelengths of light increases as the size of the particles increases.
Reason (R): Large particles scatter lights of all wavelengths equally well.

Q 28. **Assertion (A):** The scattered light makes path of light visible.
Reason (R): Scattering of light is the result of Tyndall effect.

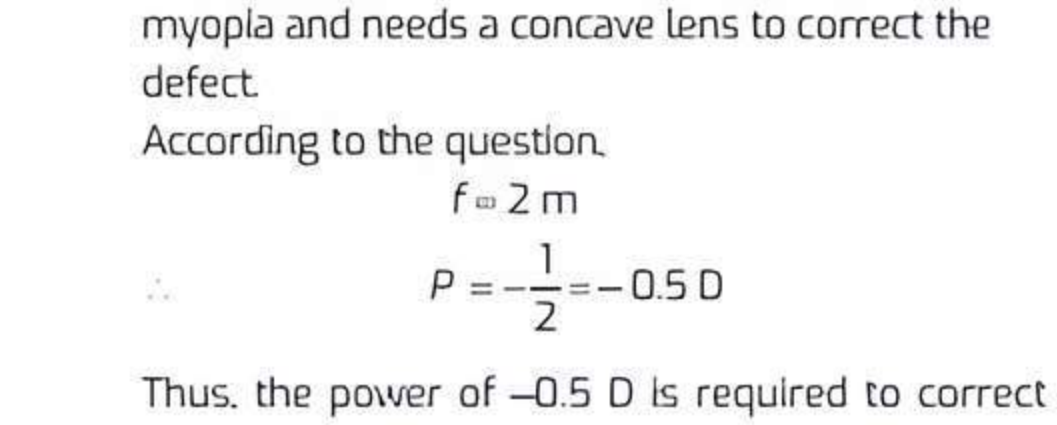
Answers

1. (a) refraction
2. (b) A–3, B–1, C–4, D–2
3. (b) pupils take time to adjust
4. (b) outer surface of the cornea
5. (c) remains unchanged
6. (d) The person mentioned here is suffering from myopia and needs a concave lens to correct the defect.
According to the question,

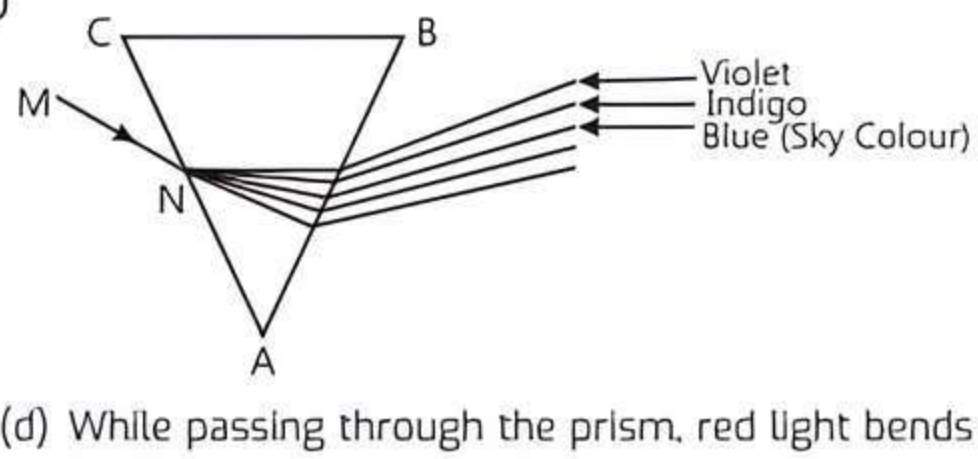
$$f = 2 \text{ m}$$

$$\therefore \quad P = -\frac{1}{2} = -0.5 \text{ D}$$

Thus, the power of –0.5 D is required to correct this defect.
7. (d) Both a. and b.
8. (a) Weakening of ciliary muscles.
9. (d) opaque eye lens
10. (c) it bends towards the base
11. (a) prism
12. (b) Generally, in case of a prism (i), the formation of spectrum is shown below:



In the above figure, from top the third colour is yellow. But we can see that from bottom the third colour is blue (colour of sky). So, we can obtain the correct situation by inverting the prism. Thus, the required orientation can be found in case (ii).



13. (d) While passing through the prism, red light bends the least and violet light the most.
14. (c) Colour used to paint the danger signals
15. (c) Refraction, dispersion and internal reflection
16. (a) scattering of light is not enough at such heights
17. (b) refraction of light by different layers of varying refractive indices
18. (c) scattering of light
19. (d) Clouds look white because water droplets present in the atmosphere scatters all wavelengths due to their large size.
20. (d) atmospheric refraction
21. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
22. (c) Reason (R) is false because a diverging lens or concave lens is used for the correction of myopic eye.
23. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
24. (d) Assertion (A) is false because planets do not twinkle while stars twinkle.
25. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
Just after the rain, a large number of small droplets of water remain suspended in the air. Each drop acts like a small prism. When sunlight fall on these drops the white light splits into seven colours. The dispersed light from a large number of drops forms a continuous band of seven colours.

26. (c) Reason (R) is false because the time difference between actual sunset and apparent sunset is 2 minutes

27. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

28. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

The triangular glass prism is a transparent object made of glass having two triangular ends and three rectangular sides. The opposite faces of a triangular glass prism are not parallel to one another.

When a ray of light passes through a prism, it bends towards the base of prism. But when white light consisting of seven colours falls on a glass prism, each colour in it is refracted by a different angle, with the result that seven colours are spread out to form a spectrum. The red colour is deviated the least and the violet colour is deviated the maximum.

Read the above passage carefully and give the answer of the following questions:

Q 1. Angle of deviation in a prism is the angle between:

a. incident and reflected ray
b. reflected and emergent ray
c. incident and emergent ray
d. incident and refracted ray

Q 2. Which of the following phenomenon of light are involved in the formation of a rainbow?

a. Reflection, refraction and dispersion
b. Refraction, dispersion and total internal reflection
c. Refraction, dispersion and internal reflection
d. Dispersion, scattering and total internal reflection

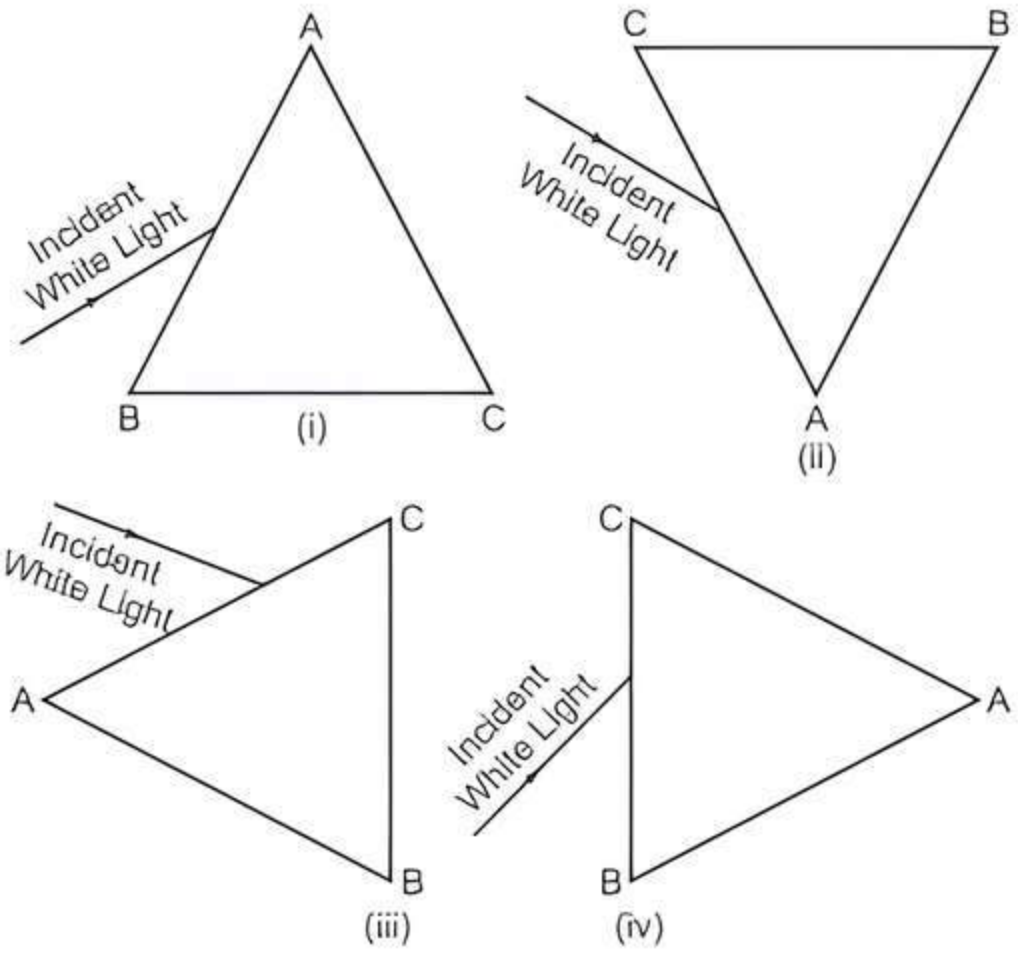
Q 3. Which of the following coloured light has the least speed in glass prism?

a. Violet b. Yellow c. Red d. Green

Q 4. The colour of light which undergoes least bending on passing through the glass prism is:

a. green b. violet c. red d. blue

Q 5. Based on the different orientations of a prism ABC given below, in which of the following cases, after dispersion, the third colour from the top corresponds to the colour of the sky?



a. (I) b. (II) c. (III) d. (IV)

Answers

1. (c) Incident and emergent ray
2. (c) Refraction. dispersion and internal reflection
3. (a) Violet
4. (c) red
5. (b) (ii)

Case Study 2

We know that when light goes from one medium to another medium having different optical densities, then refraction of light rays (or bending of light rays) takes place. Now, in the atmosphere, we have air everywhere. But all the air in the atmosphere is not at the same temperature. Some of the air layers of the atmosphere are cold whereas other air layers of the atmosphere are comparatively warm (or hotter). Now the cooler air layers of the atmosphere behave as optically denser medium for light rays whereas the warmer air layers (or hotter air layers) of the atmosphere behave as optically rarer medium for the light rays. So, in the same atmosphere we have air layers having different optical densities. And when light rays pass through the atmosphere having air layers of different optical densities, then refraction of light takes place. The refraction of light caused by the Earth's atmosphere (having air layers of varying optical densities) is called atmospheric refraction.

Read the above passage carefully and give the answer of the following questions:

Q 1. With respect to atmospheric refraction which of the following point distinguish between cold air and hot air?

a. Cold air is denser than hot air
b. Hot air is lighter than cold air
c. Cold air has higher refractive index than hot air.
d. All of the above

Q 2. What is the reason behind twinkling of Stars?

a. Dispersion of star light
b. Reflection of star light
c. Refraction of star light
d. All of the above

Q 3. Why Sun appears flattened during sunrise and sunset?

a. Because Sun is closer to Earth
b. Because Earth is rotating
c. Because Earth is revolving
d. Because of atmospheric refraction

Q 4. How much time from sunrise to sunset is lengthened because of atmospheric refraction?

a. 4 hours
b. 2 minutes
c. 4 minutes
d. 2 hours

Q 5. When light rays from Stars enter into Earth's atmosphere, it travels from:

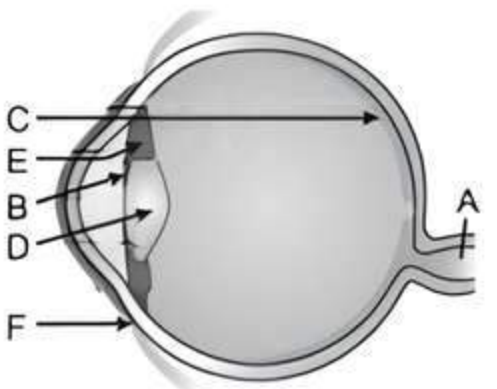
a. denser to rarer medium
b. rarer to denser medium
c. rarer medium to vacuum
d. denser medium to vacuum

Answers

1. (d) All of the above
   Cold air is denser and heavier than hot air. Also, cold air has higher refractive index than hot air. Hence, all are true.
2. (c) refraction of star light
3. (d) The Sun appears flattened because of atmospheric refraction.
4. (c) The time from sunrise to sunset is lengthened by 4 minutes.
5. (b) When light rays from Stars enter into Earth's atmosphere, it travel from rarer to denser medium.

Case Study 3

Different organs of human eye are labelled as A to F.



The Structure of Human Eye

Study the diagram and answer the following questions:

Q 1. Name the parts A, B, C, D and E.

Q 2. What is the nature of image formed on the retina of the eye?

Q 3. When light rays enter the eye, most of the refraction occurs at the:

(i) part D **(ii) part B**
(iii) outer surface of part F **(iv) part E**

Q 4. Define power of accommodation.

Q 5. What is aqueous humour and vitreous humour?

Answers

1. A—Optic nerve; B—Iris; C—Retina; D—Crystalline lens; E—Ciliary muscles
2. Real and inverted
3. (iii) outer surface of part F
4. The ability of eye lens to adjust its focal length is called power of accommodation.
5. The space between cornea and eye lens is filled with a watery liquid called aqueous humour, whereas vitreous humour is a transparent jelly-like substance filled between eye lens and retina.

Case Study 4

When light goes from one medium to another medium having different optical densities, then refraction of light rays takes place. All the air in the atmosphere is not at the same temperature. Some of the air layers of the atmosphere are cold (optically denser) whereas other layers of the atmosphere are comparatively warm (optically rarer). So, in the atmosphere we have air layers having different optical densities.

Atmospheric refraction is the deviation of light from a straight line as it passes through the atmosphere due to the variation in air density. Such refraction can raise or lower, or stretch or shorten the images of distant objects and can also make distant objects appear to twinkle or shimmer.

Read the above passage carefully and give the answer of the following questions:

Q 1. What is atmospheric refraction?

Q 2. What causes atmospheric refraction?

Q 3. Name the effects produced by atmospheric refraction.

Q 4. Which has more refractive index-hot air or cold air?

Q 5. How much time from sunrise to sunset is lengthened because of atmospheric refraction?

Answers

1. The refraction of light caused by the Earth's atmosphere (having air layers of varying optical densities) is atmospheric refraction.
2. It is caused due to the varying optical densities of different layers of Earth's atmosphere.
3. Twinkling of Stars, the Stars seem higher than they actually are and advanced sunrise and delayed sunset are some phenomenon produced by atmospheric refraction.
4. The refractive index of hot air is less than cold air because cold air is denser than hot air.
5. The sunrise appears 2 minutes early and sunset appears 2 minutes later due to atmospheric refraction. So, total time lengthened is 4 minutes.

Very Short Answer Type Questions

Q 1. State one function of crystalline lens in human eye.

Ans. The crystalline lens provides the finer adjustment of focal length required to focus objects at different distances on the retina.

Q 2. How is the sense of vision carried from the eye to the brain?

Ans. The sense of vision is carried from the eye to the brain through optic nerve.

Q 3. What is the range of vision for a normal human eye?

Ans. For a normal human eye, the range of vision is from 25 cm to infinity.

Q 4. What is meant by far point of the eye?

Ans. The farthest point up to which the eye can see objects clearly is called the far point of the eye. It is infinity for a normal eye.

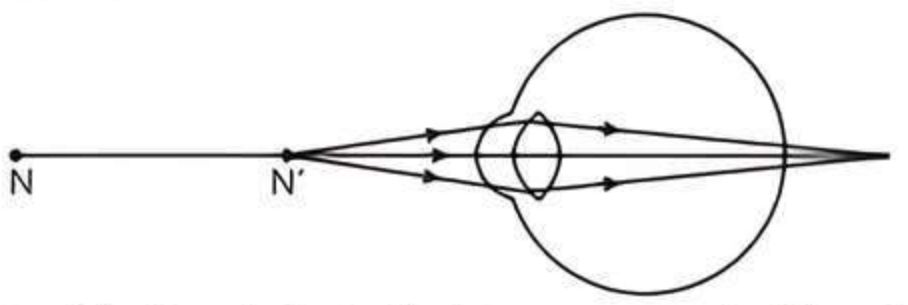
Q 5. Why is a normal eye not able to see clearly the objects placed closer than 25 cm? *(NCERT EXERCISE)*

Ans. A normal eye is unable to see the objects placed closer than 25 cm because the focal length of the eye lens cannot be decreased below a certain minimum limit.

Q 6. An old person is unable to see clearly nearby objects as well as distant objects. What kind of lens will be required to see clearly nearby objects as well as distant objects?

Ans. Such people require bi-focal lenses, which consists of both concave and convex lenses to facilitate distant and near vision respectively.

Q 7. Study the diagram and answer the questions that follows:



Identify the defect of vision represented by this diagram.

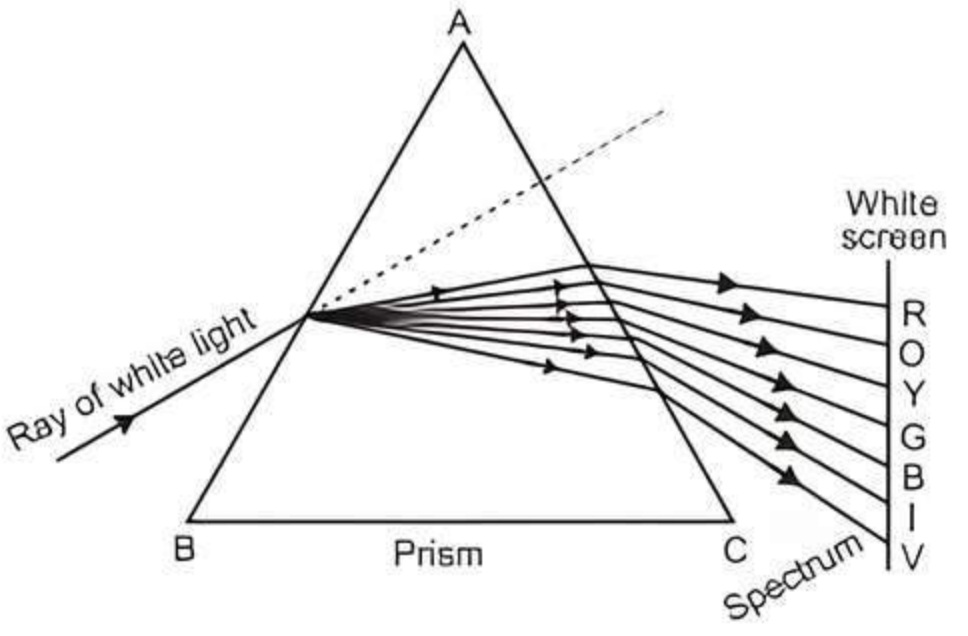
Ans. The defect of vision is hypermetropia.

Q 8. Define dispersion of white light.

Ans. The splitting of white light into its constituent colours is called dispersion.

Q 9. Draw a diagram to show the dispersion of white light by a glass prism.

Ans. Diagram showing dispersion of white light by a glass prism.



Q 10. Name the type of particles which act as prisms in the formation of rainbow in the sky.

Ans. The tiny water droplets present in the atmosphere act like small prisms.

Q 11. Is the position of a star as seen by us is its true position? Justify your answer. *(NCERT EXEMPLAR)*

Ans. No, due to atmospheric refraction a star appears to be slightly higher than its actual position.

Q 12. Name the phenomenon responsible for apparent flattening of the Sun's disc at sunrise and sunset.

Ans. The apparent flattening of the Sun's disc at sunrise and sunset is due to atmospheric refraction.

Q 13. Which phenomenon is responsible for making the path of light visible?

Ans. Tyndall effect makes the path of light visible.

Short Answer Type-I Questions

Q 1. Define the term power of accommodation. Write the modification in the curvature of the eye lens which enables us to see the nearby objects clearly? *(CBSE 2019)*

Ans. The ability of the eye to focus on both near and distant objects, by adjusting its focal length, is called the accommodation of the eye.

While looking at nearby objects, the ciliary muscles contract which increases the curvature of eye lens. The eye lens becomes thicker and focal length of eye lens decreases which enable us to see the nearby objects clearly.

Q 2. Write the structure of eye lens and state the role of ciliary muscles in the human eye. *(CBSE 2019)*

Ans. The eye lens is a bi-convex lens made of a fibrous, jelly-like material.

The key role of ciliary muscles is to modify the curvature of eye lens and thus change its focal length.

Q 3. What happens to the image distance in the normal human eye when we decrease the distance of an object, say 10 m to 1 m? Justify your answer.

Ans. *(CBSE 2019)*

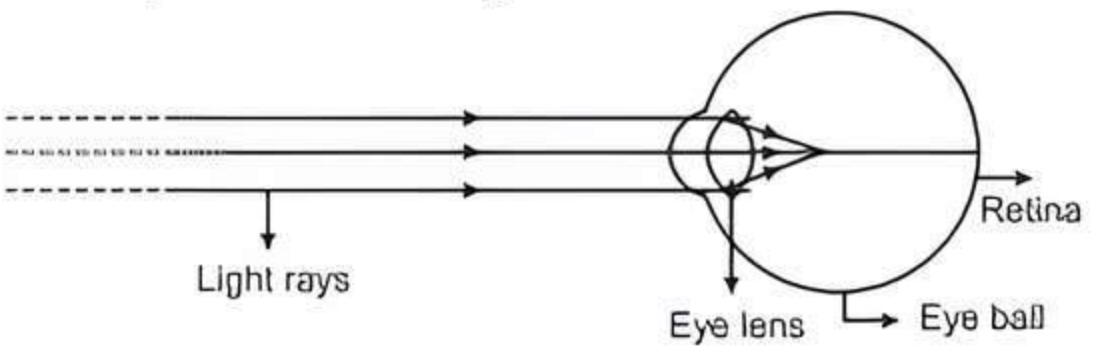
TiP

For a normal human eye, image distance is independent of object distance as image is always formed on the retina.

When we decrease the object distance from 10 m to 1 m, the focal length of eye lens accommodates itself to obtain a clear image on the retina. This is done by the action of ciliary muscles.

Therefore, the image distance remains the same.

Q 4. Observe the following diagram and answer the questions following it:



(i) Identify the defect of vision shown.

(ii) List its two causes.

(iii) Name the type of lens used for the correction of this defect. *(CBSE 2023)*

Ans. (i) Myopia

(ii) **Causes:**

(a) excessive curvature of the eye lens

(b) elongation of the eye ball

(iii) A concave lens of suitable power is used for the correction of this defect.

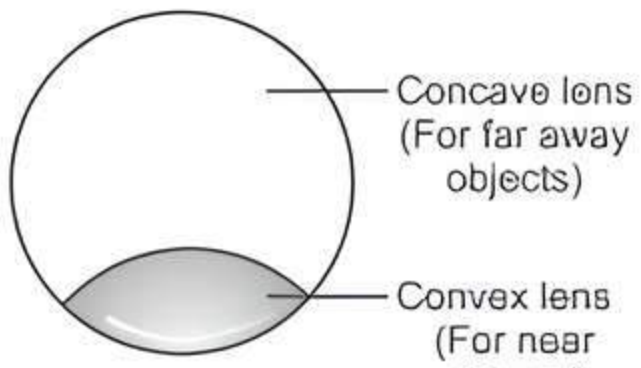
Q 5. List two causes of presbyopia. Draw labelled diagram of a lens used for the correction of this defect of vision. *(CBSE 2019)*

Ans. Presbyopia arises due to the following reasons:

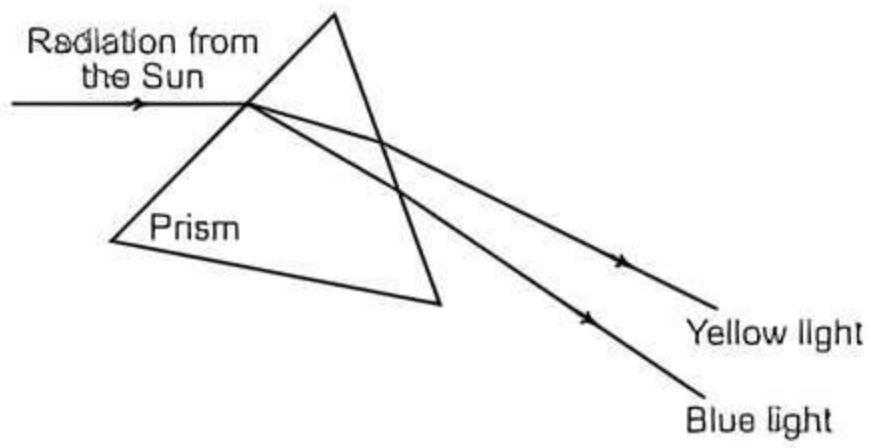
(i) gradual weakening of the ciliary muscles and

(ii) diminishing flexibility of the eye lens.

Bi-focal lens is used for the correction of this defect.



Q 6.



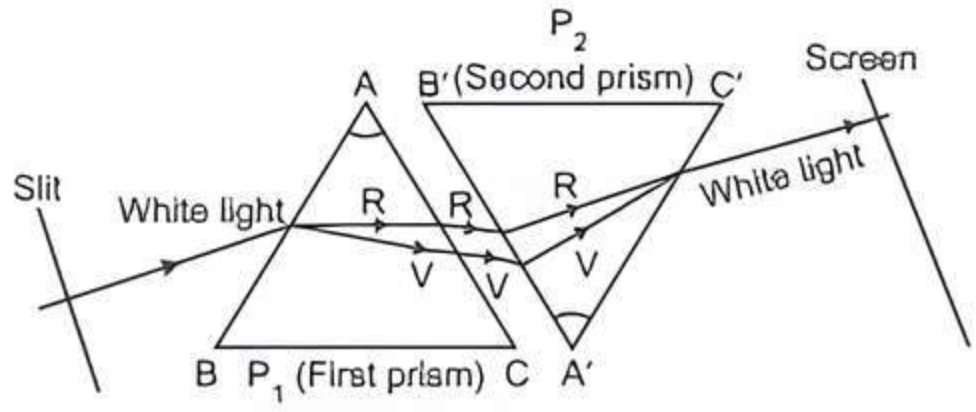
State the phenomena observed in the above diagram. Explain with reference to the diagram, which of the two lights mentioned above will have the higher wavelength? *(CBSE SQP 2022-23)*

Ans. The splitting of white light into seven colours on passing through a prism is called dispersion.

For a constant frequency, wavelength is directly proportional to velocity. So, yellow will have greater wavelength than blue as the velocity of yellow light is greater than blue light.

Q 7. How will you use two identical prisms so that a narrow beam of white light incident on one prism emerges out of the second prism as white light? Draw the diagram. *(CBSE SQP 2022-23)*

Ans. By using two identical prisms, one placed inverted with respect to the other.



Recombination of the spectrum of White light.

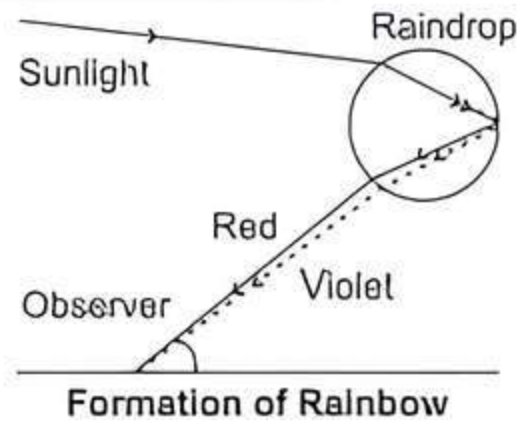
Q 8. A glass prism is able to produce a spectrum when white light passes through it but a rectangular block of same transparent glass does not produce any spectrum. Why? *(CBSE 2019)*

Ans. In a rectangular block, refraction of light takes place at the two parallel surfaces. In this case, the emergent ray is also a white light because the constituents of white light which are refracted at different angles at the first interface recombine at the second interface and emerge as a single white light.

In a prism, the two interfaces through which the light ray has to pass are not parallel to each other and are inclined at an angle. In this case, the effects of the first interface are not reversed and the colours separated at the first interface continue along different paths upon leaving the glass at the second interface. Hence, we observe a spectrum in a glass prism.

Q 9. When and where does a rainbow appear in the sky? Draw a labelled ray diagram to show its formation. *(CBSE 2023)*

Ans. A rainbow is a natural spectrum appearing in the sky after a rain shower. It is always formed in a direction opposite to that of the Sun.



Formation of Rainbow

Q 10. What is atmospheric refraction? List two phenomenon which can be explained on the basis of atmospheric refraction.

Ans. The refraction of light caused by the Earth's atmosphere (having air layers of varying optical densities) is atmospheric refraction.

Twinkling of Stars and advanced sunrise and delayed sunset are the two phenomenon based on atmospheric refraction.

TiP

Understand the concept of atmospheric refraction and the causes of phenomenon caused by atmospheric refraction.

Q 11. Explain why the planets do not twinkle.

Ans. The planets are much closer to the Earth, and are thus considered as a collection of a large number of point-sized sources of light. The total variation in the amount of light entering our eye from all the individual point-sized sources will average out to zero. Hence, the twinkling effects of the planets are nullified and they do not twinkle.

Q 12. What is scattering of light? Why does the clear sky appear blue?

Ans. When a ray of light passes through a path of suspended particles, it splits up in various random directions. Such a phenomenon is known as scattering of light.

When sunlight passes through the atmosphere, the fine particles in air scatter the blue colour (shorter wavelengths) more strongly than red. The scattered blue light enters our eyes and thus the sky appears blue.

Short Answer Type-II Questions

Q 1. (i) List the parts of the human eye that control the amount of light entering into it. Explain how they perform this function.

(ii) Write the function of retina in human eye.

(iii) What do we have to keep in mind when eyes have to be donated?

Ans. (i) Pupil controls the amount of light entering into it. The relaxation and contraction of the muscular fibres of the iris regulate the opening and closing of the pupil.

(ii) The retina is the light-sensing part of the eye. It converts the incident light into electrical signals and sends them to the brain.

(iii) Eyes must be removed within 4-6 hours after death.

Persons who were infected with or died because of AIDS, Hepatitis B or C, rabies, tetanus, cholera, etc. cannot donate eyes.

Q 2. With the help of ciliary muscles, the human eye can change its curvature and thus alter the focal length of its lens. State the changes that occur in the curvature and focal length of the eye lens while viewing (i) a distance object, (ii) nearby objects. Explain, why a normal eye is not able to see distinctly the objects placed closer than 25 cm, without putting any strain on the eye. *(CBSE 2017)*

Ans. (i) To see a distant object, the eye lens becomes thin and its focal length increases.

(ii) To see a nearby object, the eye lens becomes thicker and its focal length decreases.

A normal eye is not able to see distinctly the objects placed closer than 25 cm, without putting any strain on the eye because the focal length of the eye lens cannot be decreased below a certain minimum limit.

Q 3. A student uses spectacles of focal length −2·5 m.

(i) Name the defect of vision he is suffering from.

(ii) Which lens is used for the correction of this defect?

(iii) List two main causes of developing this defect.

(iv) Compute the power of this lens. *(CBSE 2020)*

Ans. (i) He is suffering from myopia because the focal length required for the lens is negative.

(ii) Myopia is corrected by using a concave lens of suitable power.

(iii) Myopia arises due to: (a) excessive curvature of the eye lens (b) elongation of the eyeball.

COMMON ERROR

Students get confused between the causes and corrective measure of different defects of vision.

(iv) Given, $f = -2.5$ m

We know that, $P = 1/f$

$= 1/(-2.5)$

$= -10/25 = -0.4$ D

Q 4. (i) A person is suffering from both myopia and hypermetropia.

(a) What kind of lenses can correct this defect?

(b) How are these lenses prepared?

(ii) A person needs a lens of power +3D for correcting his near vision and −3D for correcting his distant vision. Calculate the focal lengths of the lenses required to correct these defects. *(CBSE 2020)*

Ans. (i) (a) Bi-focal lenses can correct this defect.

(b) Upper portion of these lenses consists of a concave lens (to correct myopia) and the lower portion consists of a convex lens (to correct hypermetropia).

(ii) $\because \quad P = \dfrac{1}{f(\text{m})}$

$P_1 = +3$ D

$f_1 = \dfrac{1}{P} = \dfrac{1}{3} = +0.33 = 33.3$ cm

$P_2 = -3$ D

$f_2 = \dfrac{1}{-3} = -0.33 = -33.3$ cm

Q 5. Differentiate between a glass slab and a glass prism. What happens when a narrow beam of (i) a monochromatic light, and (ii) white light passes through (a) glass slab and (b) glass prism?

Ans.

TiP

Learn and understand the basic concepts of glass slab and glass prism, refraction of monochromatic light and white light through a glass slab and glass prism.

A glass slab has two parallel refracting surfaces whereas a prism has two inclined refracting surfaces.

(i) When a narrow beam of monochromatic light passes through:

(a) Glass slab: It deviates from the actual path, but the incident ray and the emergent ray of light are parallel to each other.

(b) Glass prism: It has deviated from the actual path but the incident ray and the emergent ray of light are not parallel to each other.

(ii) When a narrow beam of white light passes through:

(a) Glass slab: The splitting of white light into its constituent colours does not occur and the direction of the incident ray and the emergent ray of light are parallel to each other.

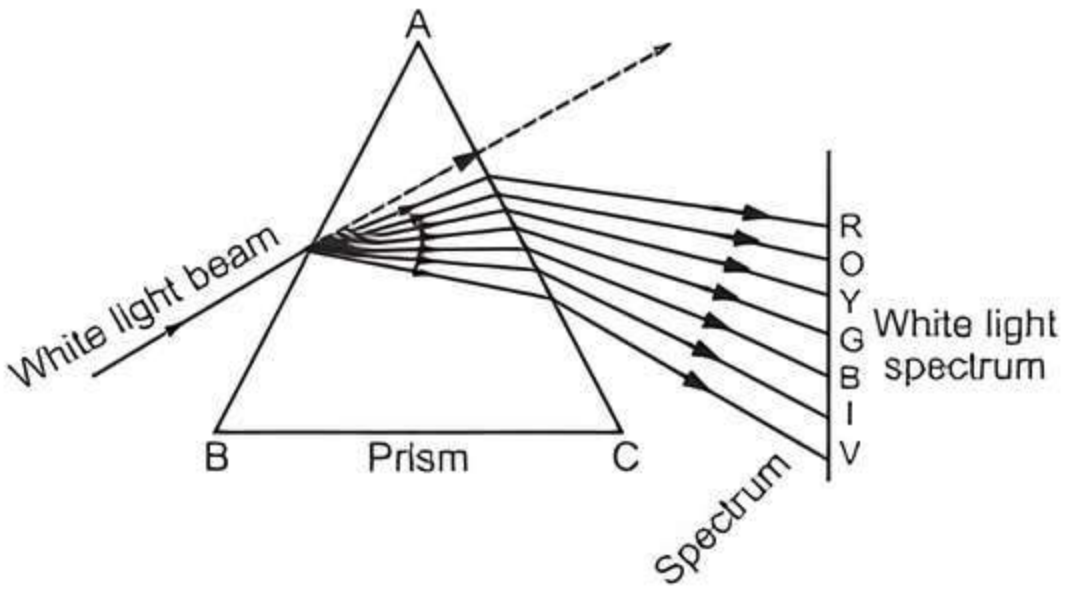
(b) Glass prism: The splitting of white light into its constituent seven colours occurs and the direction of the incident ray and the emergent ray of light is not parallel to each other.

Q 6. Define the term dispersion of white light. State the colour which bends (i) the most, (ii) the least while passing through a glass prism. Draw a diagram to show the dispersion of white light. *(CBSE 2023)*

Ans. The splitting of white light into its components due to different bending abilities of colours when it passes through a prism is called dispersion.

(i) Violet colour bends the most.

(ii) Red colour bends the least.



TiP

Draw correct and labelled diagrams. Deviation of light should be marked properly.

Q 7. (i) What is visible spectrum?

(ii) Why is red used as the stopping light at traffic signals?

(iii) Two triangular glass prisms are kept together connected through their rectangular side. A light beam is passed through one side of the combination. Will there be any dispersion? Justify your answer.

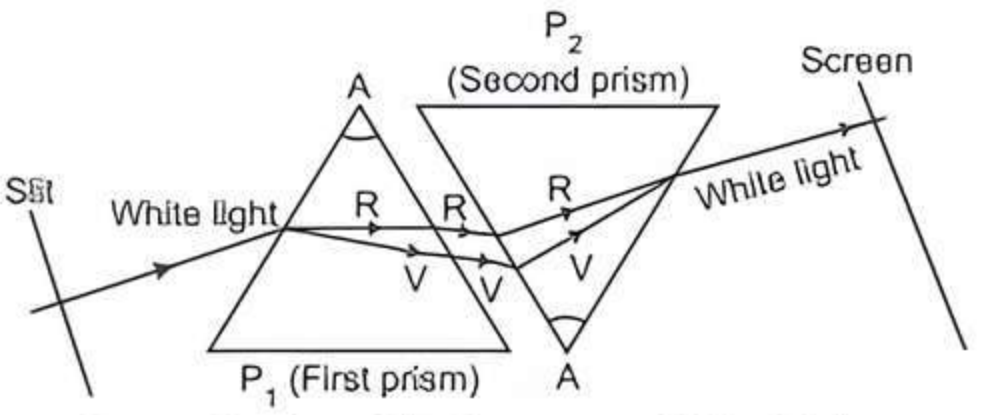
Ans. (i) Visible spectrum is the band of coloured components of a white light beam.

(ii) It is because red is least scattered by air molecules and can easily go through fog or mist or smoke. Therefore, it can be seen in the same colour even from a distant place.

(iii) No, because the given set-up will behave like a glass slab, resulting in recombination of the seven colours to produce white light.

Q 8. State the cause of dispersion of white light by a glass prism. Draw a labelled diagram to illustrate the recombination of the spectrum of white light. Why is it essential that the two prisms used for the purpose should be identical and placed in an inverted position with respect to each other?

Ans. Light rays of different colours travel with the same speed in vacuum and air, but in any other medium, they travel with the different speeds and bend through the different angles, which leads to the dispersion of light.



Recombination of the Spectrum of White Light

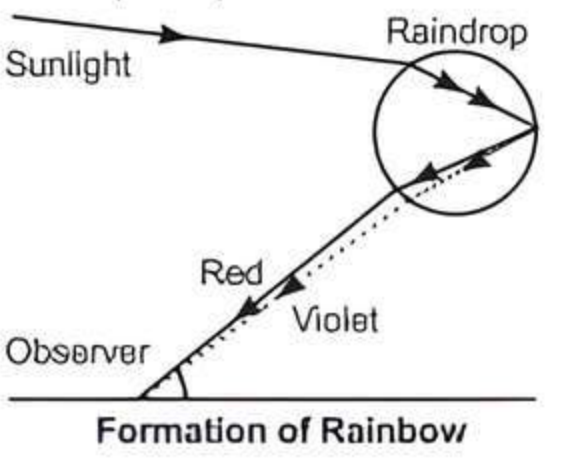
TiP

Practice drawing diagrams and don't memorise the labelling, instead try to understand them.

It is essential to place two identical prisms in an inverted position with respect to each other because the refraction produced by the second prism is equal to the refraction produced by the first prism.

Q 9. What is a rainbow? Draw a labelled diagram to show the formation of a rainbow. *(CBSE 2023, 19)*

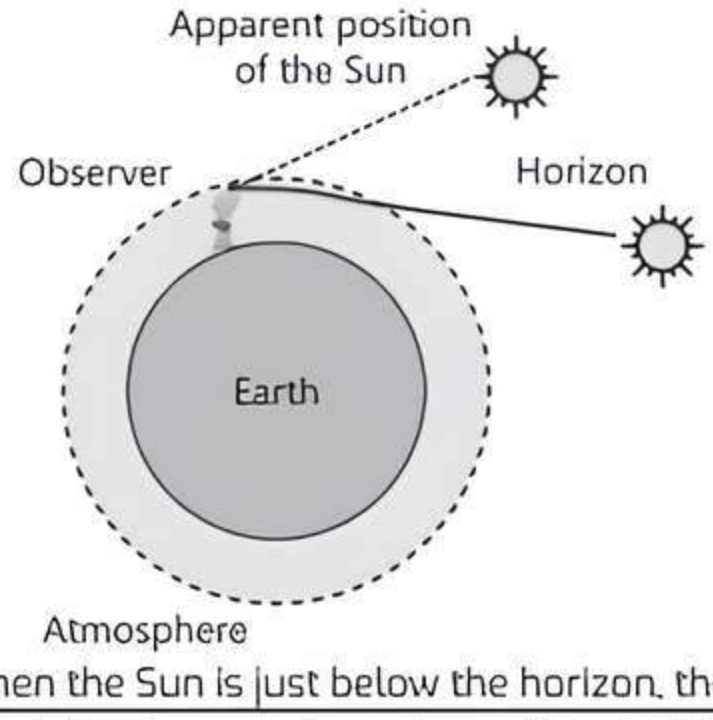
Ans. A rainbow is a natural spectrum appearing in the sky after rainfall. It is caused by dispersion of sunlight by tiny water droplets present in the atmosphere.



Formation of Rainbow

Q 10. With the help of a diagram, explain how atmospheric refraction is responsible for the advance sunrise and delayed sunset. How much time difference does it cause on the duration of day on the Earth? *(CBSE 2017)*

Ans.



When the Sun is just below the horizon, the light rays bend due to our atmosphere. Due to this, the Sun appears to be at an apparent position and becomes visible to us before actual sunrise. Similarly, at sunset, due to bending of light rays we see the apparent position of the Sun and the Sun is visible for a longer time.

Hence, the Sun is visible to us about 2 minutes before the actual sunrise and about 2 minutes after the actual sunset.

Q 11. Why is Tyndall effect shown by colloidal particles? State four instances of observing the Tyndall effect.

(CBSE 2020)

Ans. Tyndall effect is shown by colloidal particles because of the phenomenon of scattering of light.

Four instances of observing the Tyndall effect:

(i) It can be observed when a fine beam of light enters a room through a small hole.

(ii) When sunlight passes through the canopy of a dense forest.

(iii) Visible beam of headlights in fog is caused by the Tyndall effect.

(iv) It is the reason for the blue colour of the sky.

Long Answer Type Questions

Q 1 (i) Write the functions of each of the following parts of the human eye:

(a) Cornea

(b) Iris

(c) Crystalline (Eye) lens

(d) Ciliary muscles

(e) Retina

(ii) A person is unable to see distinctly the objects closer than 1 m. Name the defect of vision he is suffering from. Draw ray diagrams to illustrate the cause of the defect and its correction by suitable lens. *(CBSE 2017)*

Ans.

TiP

While learning the human eye, lay stress on the function of each part of the human eye.

(i) **(a) Cornea:** It focuses the light that enter the eye by refracting the light towards the lens.

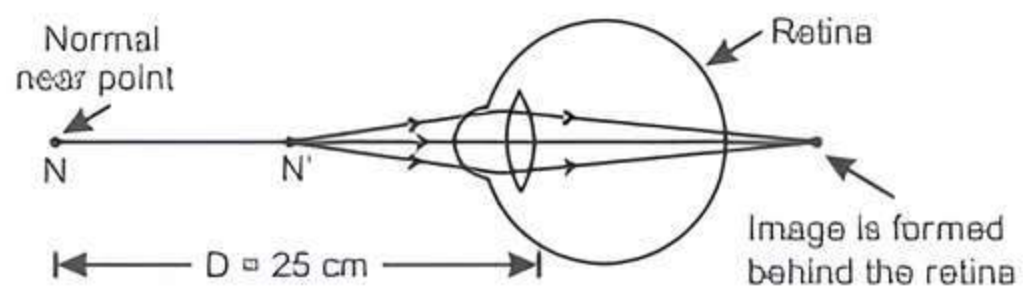
(b) Iris: It regulates and controls the amount of light entering the eye by adjusting the size of the pupil.

(c) Crystalline Lens: It provides adjustment of focal length required to focus objects at different distances on the retina.

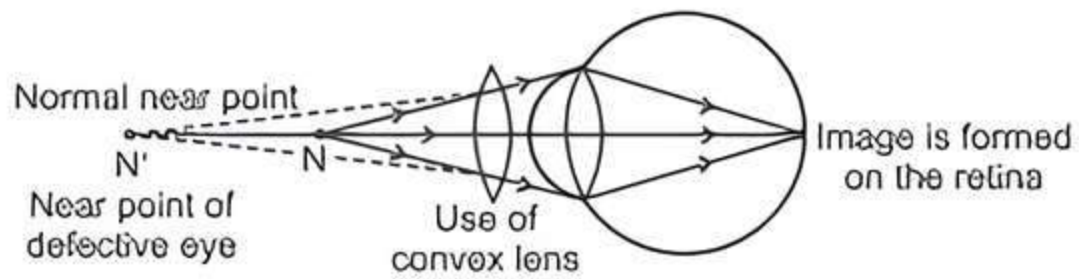
(d) Ciliary Muscles: It controls the focal length of the eye lens.

(e) Retina: It acts as a screen on which image is formed in the eye. converts incident light into electrical signals and sends them to the brain.

(ii) The person is suffering from hypermetropia.



Correction:



Q 2. (i) A student suffering from myopia is not able to see distinctly the objects placed beyond 5 m. List two possible reasons due to which this defect of vision may have arisen. With the help of ray diagrams, explain:

(a) why the student is unable to see distinctly the objects placed beyond 5 m from his eyes.

(b) the type of the corrective lens used to restore proper vision and how this defect is corrected by the use of this lens.

(ii) If, in this case, the numerical value of the focal length of the corrective lens is 5 m, find the power of the lens as per the new Cartesian sign convention. *(CBSE 2017)*

Ans.

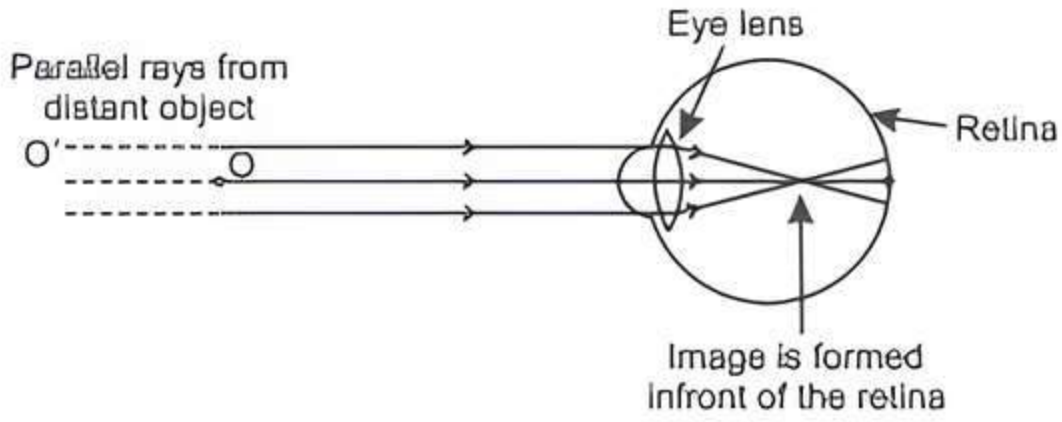
TiP

Distinctly learn the causes and corrective measures of defects of vision. Practice drawing the ray diagrams with proper labellings.

(i) Two reasons due to which myopia has arisen are:

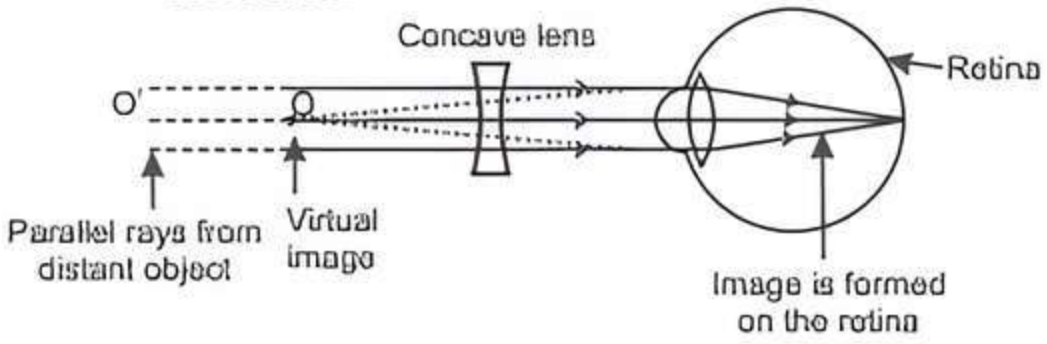
- excessive curvature of eye lens.
- elongation of eyeball.

(a) Student is unable to see distinctly the objects placed beyond 5 m because images of objects placed beyond 5 m are formed in front of the retina and not at the retina itself.



(b) A concave lens of suitable power is used to restore proper vision.

A concave lens of suitable power will bring the image back on to the retina and thus myopia is corrected.



(ii) Given. $f = -5$ m (corrective lens is concave)

$$P = \frac{1}{f(\text{in m})} = \frac{1}{-5}$$

$$P = -0.2\text{D}$$

Q 3. When do we consider a person to be myopic or hypermetropic? List two causes of hypermetropia. Explain using ray diagrams how the defect associated with hypermetropic eye can be corrected. *(CBSE 2019)*

Ans. When a person is unable to clearly see distant objects, he is suffering from myopia. This happens when image is formed in front of the retina.

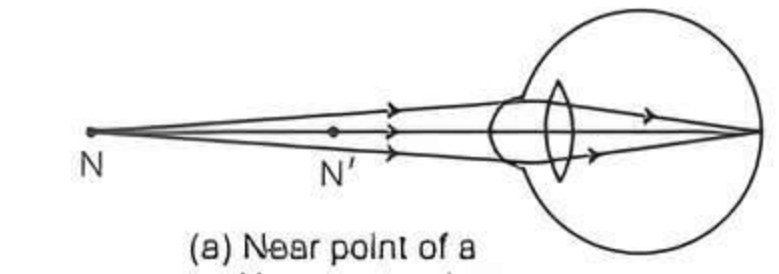
When a person is unable to clearly see a nearby object, he is suffering from hypermetropia. This happens when image is formed behind the retina.

Causes of hypermetropia:

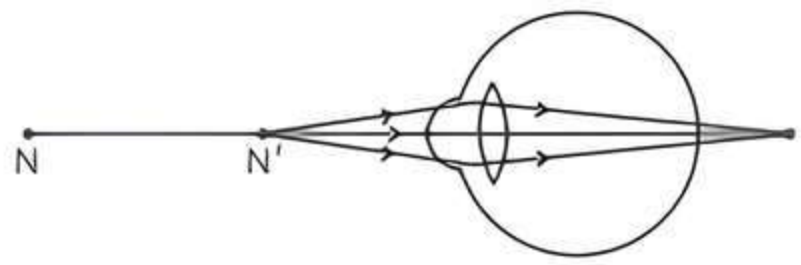
(I) Increase in focal length of eye lens

(ii) Decrease in the length of eyeball

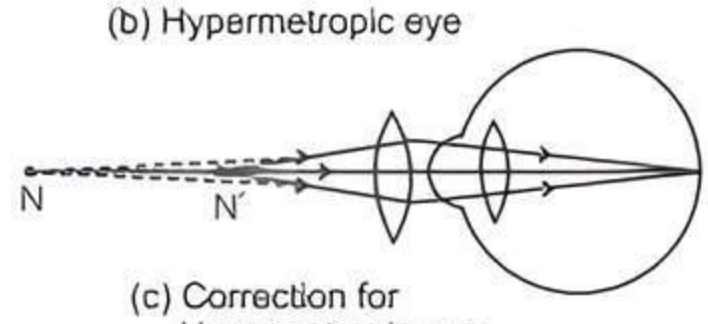
Hypermetropia is corrected by using a convex lens of appropriate power placed in front of eye. It shifts the image back onto the retina instead of behind the retina and the defect is corrected.



(a) Near point of a Hypermetropic eye



(b) Hypermetropic eye



(c) Correction for Hypermetropic eye

COMMON ERROR

Mostly students commit errors in drawing myopic/ hypermetropic eye and its correction.

Chapter Test

Multiple Choice Questions

Q 1. The angle between the two rectangular surfaces of a prism is called:

a. angle of prism
b. refracting angle
c. Both a. and b.
d. None of the above

Q 2. The human eye can focus objects at different distances by adjusting focal length of the eye lens. This is due to:

a. presbyopia
b. accommodation
c. near-sightedness
d. far-sightedness

Q 3. The sky generally appears blue, because the colour which scatters closed to eye is:

a. violet
b. indigo
c. blue
d. violet and indigo

Q 4. The deflection of light by minute particles and molecules of the atmosphere in all directions is called ..... of light.

a. dispersion
b. scattering
c. interference
d. Tyndall effect

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): Higher the refracting index of the prism material lower is the angle of deviation.
Reason (R): The angle of deviation is directly proportional to the angle of prism.

Q 6. Assertion (A): Rainbow is an example of the dispersion of sunlight by the water droplets.
Reason (R): Light of shorter wavelength is scattered much more than light of larger wavelength.

Case Study Based Question

Q 7. Figures A and B show the ray diagrams related to defects of vision.

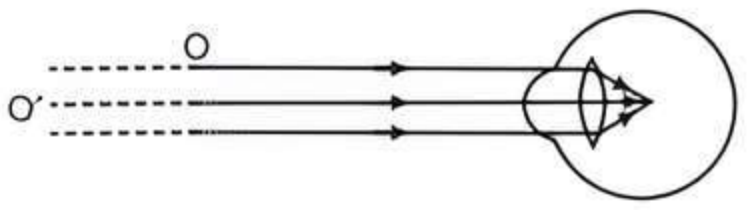


Fig. A: Defect of vision in patient X

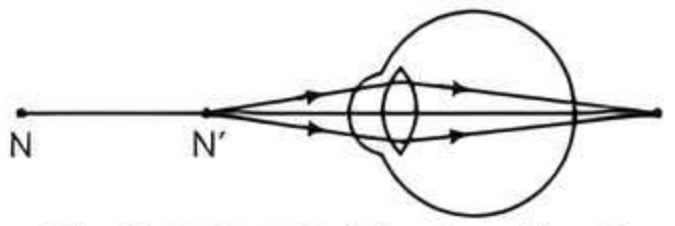


Fig. B: Defect of vision in patient Y

Read the above passage carefully and give the answer of the following questions:

(i) Refer to fig. B and fig. A, showing the defects of vision in patients *Y* and *X*. Infer the defects which can be diagnosed from the given ray diagrams.

(ii) The patient X needs a lens of power −4.5D for correction of his vision.
  (a) What is the focal length of the corrective lens?
  (b) What is the nature of corrective lens?

(iii) Based on the spectacles given below, infer the eye defect which can be diagnosed from it. Also list two causes of this defect.

(iv) Identify the eye defect resulting due to the eye lens becoming cloudy.

Very Short Answer Type Questions

Q 8. What is meant by scattering of light?

Q 9. When is the thickness of the eye lens minimum?

Short Answer Type-I Questions

Q 10. Why the eye lens is not perfectly solid?

Q 11. Calculate maximum power of accommodation of a person having normal vision.

Q 12. Name the phenomenon associated with the following:
  (i) The sky appears blue
  (ii) Formation of a rainbow in the sky.

Short Answer Type-II Questions

Q 13. The near point of a hypermetropic person is 75 cm from the eye. What is the power of the lens required to enable him to read clearly a book held at 25 cm from the eye?

Q 14. What is presbyopia? How can it be corrected?

Q 15. (i) Define angle of deviation.
  (ii) Show the angle of deviation for red colour when white light passes through a prism.

Long Answer Type Questions

Q 16. (i) Demonstrate an activity with a well labelled diagram to prove that white light is made up of seven colours.
  (ii) Which colour of light bends least and which one the most while passing out from the prism? Also state the reason for the same.

Q 17. (i) List three common refractive defects of vision. Suggest the way of correcting these defects.
  (ii) Explain the reason why stars appear to twinkle and the planets do not twinkle.

11 Electricity

Fastrack Revision

- **Electric Charge:** It is the property of matter due to which it produces and experience electrical and magnetic effects. There exist two types of charges in nature-(i) Positive charge and (ii) Negative charge. Like charges repel each other and unlike charges attract each other. SI unit of charge is coulomb (C).

  Electric charge $(Q) = ne$,

  where,

  n = number of electrons and

  e = charge on one electron (-1.6×10^{-19} C)

- **Coulomb:** One coulomb is defined as the amount of charge which repels an equal and similar charge with a force of 9×10^9 N when placed in vacuum at a distance of 1 metre from it.

- **Conductor:** It is a substance which allows passage of electric charges through it easily. It offers very low resistance to the flow of current. *e.g.*, copper, silver, aluminium, etc.

- **Insulator:** It is a substance that has finitely high resistance and does not allow electric current to flow through it. *e.g.*, rubber, glass, plastic, ebonite, etc.

- **Electric Current:** It is defined as the rate of flow of electric charge through any section of a conductor.

$$\text{Electric current } (I) = \frac{\text{Charge } (Q)}{\text{Time } (t)} = \frac{ne}{t} \qquad (\because Q = ne)$$

  The SI unit of electric current is ampere (A). Electric current is a scalar quantity. It is measured by an instrument called ammeter.

- **One Ampere:** When 1 coulomb of charge flows through a conductor in 1 second, then current passing through the conductor is 1ampere.

$$1 \text{ ampere} = \frac{1 \text{coulomb}}{1 \text{second}} = \frac{1\text{C}}{1\text{s}}$$

- **Electric Circuit:** It is a continuous and closed path along which electric current flows.

- **Electric Field:** It is the region around a charged body within which its influence can be experienced.

- **Electrostatic Potential:** It is the amount of work done in bringing a unit positive charge from infinity to that point. Its unit is volt.

- **Electric Potential Difference:** It is the amount of work done in bringing a unit positive charge from one point to another. SI unit of potential difference is volt (V).

$$\text{Potential difference} = \frac{\text{Work done}}{\text{Charge}} \text{ or } V = \frac{W}{Q}$$

- **One Volt:** When one joule work is done to move a unit charge from one point to another, then the potential difference between two points is one volt.

$$1\text{V} = \frac{1 \text{ Joule}}{1 \text{ coulomb}} \text{ or } 1\text{V} = \frac{1\text{J}}{1\text{C}}$$

- **Ammeter:** It is a device used to measure current in a circuit. It is always connected in series in a circuit.

- **Voltmeter:** It is a device used to measure potential difference. It is always connected in parallel to the component across which the potential difference is to be measured.

- **Ohm's Law:** This law states that the current passing through a conductor is directly proportional to the potential difference across its ends, provided the physical conditions like temperature, density, etc. remains unchanged.

$$V \propto I$$

or $$V = IR$$

where, R is the constant, called resistance of the conductor.

MNEMONICS

Concept : *Ohm's law*
Mnemonics: ***V****ampires* ***A****re* ***R****are*
Interpretation: *Voltage = Ampere × Resistance*

- **Resistance:** The resistance of a conductor is the ratio of the potential difference (p.d.) across its ends and the current flowing through it. It is a scalar quantity. SI unit of resistance is ohm (Ω).

$$\text{Resistance } (R) = \frac{\text{Potential difference } (V)}{\text{Current } (I)}$$

  The factors on which the resistance of a conductor depends are:

  (i) The resistance of a conductor (R) is directly proportional to its length (l).

  i.e., $R \propto l$

  (ii) The resistance of a conductor (R) is inversely proportional to its area of cross-section (A).

  i.e., $R \propto 1/A$

  On combining, we get

$$R \propto l/A$$

  or $$R = \rho\,(l/A)$$

  or $$\rho = RA/l$$

  where, ρ is called the electrical resistivity of the material of the conductor. Its SI unit is Ωm.

  (iii) The resistance of conductor also depends on the nature of its material.

- **Ohm:** It is the SI unit of resistance. A conductor has a resistance of one ohm if the potential difference across the two ends of a conductor is 1V and the current through it is 1A.

$$1 \text{ ohm} = \frac{1 \text{volt}}{1 \text{ampere}} \text{ or } 1\Omega = \frac{1\text{V}}{1\text{A}}$$

- **Resistances in Series:** When two or more resistances are joined end-to-end so that the same current flows through each of them, it is called a series combination of resistances.
  Here, the total resistance is equal to the sum of the individual resistances.

$$R_S = R_1 + R_2 + R_3 + ...$$

- **Resistances in Parallel:** When two or more resistances are connected between two common points such that the same potential difference is applied across each of them, it is called a parallel combination of resistances.
  Here, the reciprocal of their combined resistance is equal to the sum of the reciprocals of the individual resistances.

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$$

- **Joule's Law of Heating:** It states that the heat produced in a conductor is directly proportional to:
  (i) the square of the current 'I' through it,
  (ii) its resistance 'R' and
  (iii) the time 't', for which current is passed.
  It can be expressed as

$$H = I^2Rt \text{ joule} = \frac{I^2}{4.18} \text{ cal or } H = VIt \text{ joule } \frac{VIt}{4.18} \text{ cal}$$

- **Electric Power:** It is the rate at which electric energy is consumed by an appliance in an electric circuit.
  $P = W/t = VI = I^2R = V^2/R$
- **Watt:** It is the SI unit of power. The power of an appliance is 1 watt if one ampere of current flows through it on applying a potential difference of 1 volt across its ends.

$$1 \text{ watt} = \frac{1 \text{ joule}}{1 \text{second}} = 1 \text{volt} \times 1 \text{ampere}$$

  or $1 \text{ W} = 1 \text{Js}^{-1} = 1 \text{ V-A}$
- **Kilowatt Hour:** It is the commercial unit of electric energy. One kilowatt hour is the electric energy consumed by an appliance of 1000 watts when used for one hour.

$$1 \text{ kilowatt hour (kWh)} = 3.6 \times 10^6 \text{ J}$$

- For commercial scale, $E = P \times t$
  where, power is in kilowatt and time is in hours.

Practice Exercise

Multiple Choice Questions

Q 1. Match the quantities given in Column (A) with their SI unit given in Column (B):

Column (A)		Column (B)	
A.	Electric potential difference	1.	Ohm
B.	Resistivity	2.	Volt
C.	Resistance	3.	Coulomb
D.	Electric charge	4.	Ohm-metre

	A	B	C	D
a.	2	1	4	3
b.	3	2	4	1
c.	3	4	1	2
d.	2	4	1	3

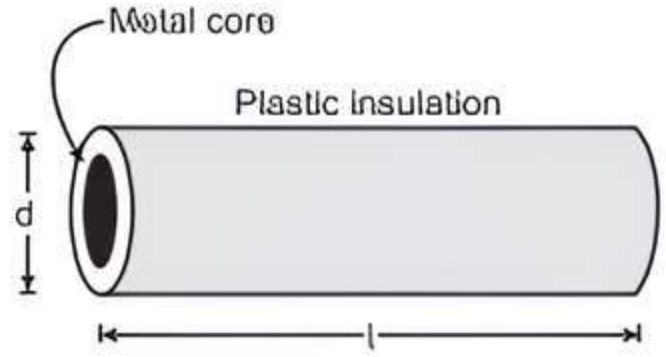
Q 2. For verifying Ohm's law, we design an electric circuit diagram in which we show the arrangement of different circuit components. We find that with respect to the resistor, the: *(CBSE 2023)*

a. ammeter is connected in parallel and the voltmeter in series.
b. ammeter is connected in series and the voltmeter in parallel.
c. ammeter and voltmeter are both connected in series.
d. ammeter and voltmeter are both connected in parallel.

Q 3. According to Ohm's law, the ends of a metallic wire is directly proportional to current, provided its ..... remains constant.

a. area b. volume
c. length d. temperature

Q 4. Plastic insulation surrounds a wire having diameter d and length l as shown in figure. A decrease in the resistance of the wire would be produced by an increase in the: *(CBSE SQP 2022-23)*



a. length l of the wire
b. diameter d of the wire
c. temperature of the wire
d. thickness of the plastic insulation

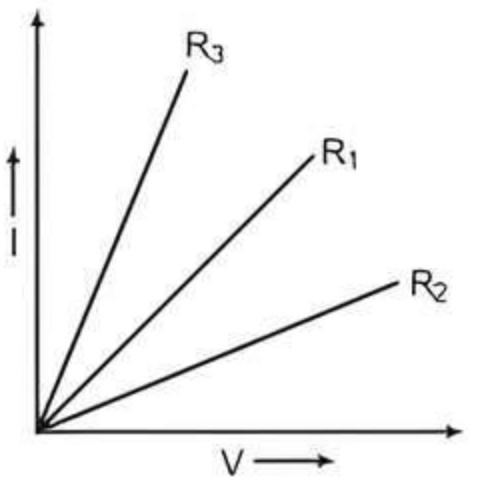
Q 5. A complete circuit is left on for several minutes, causing the connecting copper wire to become hot. As the temperature of the wire increases, the electrical resistance of the wire: *(CBSE SQP 2022-23)*

a. decreases
b. remains the same
c. increases
d. increases for some time and then decreases

Q 6. A cylindrical conductor of length l' and uniform area of cross-section A has resistance R. Another conductor of length 2.5 l and resistance 0.5 R of the same material has area of cross-section: *(CBSE 2020)*

a. 5 A b. 2.5 A c. 0.5 A d. (1/5) A

Q 7. A student plots *V-I* graphs for three samples of nichrome wire with resistances R_1, R_2 and R_3. Choose from the following statement that holds true for this graph: *(CBSE 2020)*



a. $R_1 = R_2 = R_3$ b. $R_1 > R_2 > R_3$
c. $R_3 > R_2 > R_1$ d. $R_2 > R_1 > R_3$

Q 8. When a 4 V battery is connected across an unknown resistor there is a current of 100 mA in the circuit. The value of the resistance of the resistor is:

a. 4 Ω b. 40 Ω c. 400 Ω d. 0.4 Ω

Q 9. Two LED bulbs of 12 W and 6 W are connected in series. If the current through 12 W bulb is 0.06 A the current through 6 W bulb will be:

a. 0.04 A b. 0.06 A
c. 0.08 A d. 0.12 A

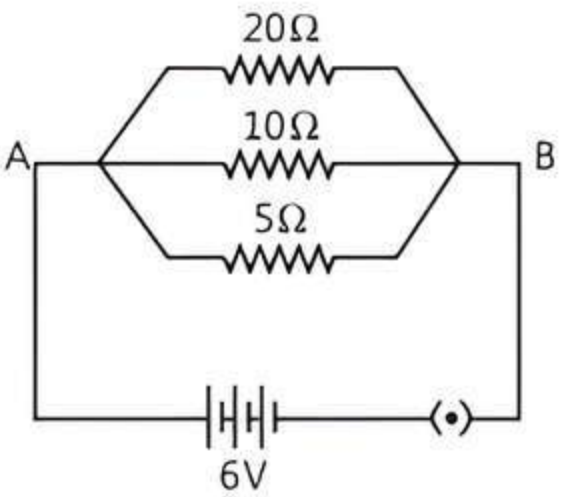
Q 10. The maximum resistance which can be made using four resistors each of resistance (1/2) Ω is: *(CBSE 2020)*

a. 2 Ω b. 1 Ω c. 2.5 Ω d. 8 Ω

Q 11. Three resistances of 2, 3 and 5 Ω are connected in parallel to a 10 V battery of negligible internal resistance. The potential difference across the 3 Ω resistance will be:

a. 2 V b. 3 V c. 5 V d. 10 V

Q 12. Calculate the current flowing through the 10 Ω resistor in the following circuit.



a. 1.2 A b. 0.6 A c. 0.2 A d. 2.0 A

Q 13. In an electrical circuit three incandescent bulbs *A*, *B* and *C* of rating 40 W, 60 W and 100 W respectively are connected in parallel to an electric source. Which of the following is likely to happen regarding their brightness? *(NCERT EXEMPLAR)*

a. Brightness of all the bulbs will be the same
b. Brightness of bulb *A* will be the maximum
c. Brightness of bulb *B* will be more than that of *A*
d. Brightness of bulb *C* will be less than that of *B*

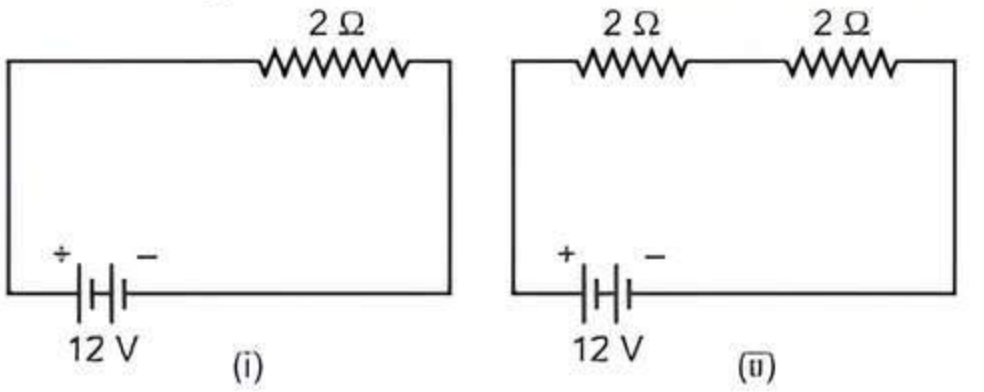
Q 14. The resistance of a resistor is reduced to half of its initial value. In doing so, if other parameters of the circuit remain unchanged, the heating effects in the resistor will become: *(CBSE 2020, 23)*

a. two times b. half
c. one-fourth d. four times

Q 15. In a resistive circuit, if the current is increased to two times, the percentage change in the amount of heat dissipated in the circuit would be: *(CBSE 2023)*

a. 400% b. 300%
c. 200% d. 100%

Q 16. In the following circuits, heat produced in the resistor or combination of resistors connected to a 12 V battery will be: *(NCERT EXEMPLAR)*



a. same in all the cases b. minimum in case (I)
c. maximum in case (II) d. maximum in case (III)

Q 17. At the time of short circuit, the electric current in the circuit:

a. vary continuously b. does not change
c. reduces substantially d. increases heavily

Q 18. A bulb is rated as 270 V, 0.5 A. Its power is:

a. 125 W b. 100 W c. 60 W d. 135 W

Q 19. An electric kettle consumes 1 kW of electric power when operated at 220 V. A fuse wire of ..... rating must be used for it.

a. 1 A b. 2 A c. 5 A d. 4 A

Q 20. Unit of electric power may also be expressed as:

a. volt-ampere b. kilowatt-hour
c. watt-second d. joule-second

Assertion & Reason Type Questions

Directions (Q. Nos. 21-28): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 21. Assertion (A): If a graph is plotted between the potential difference and the current flowing, the graph is a straight line passing through the origin.
Reason (R): The current is directly proportional to the potential difference.

Q 22. Assertion (A): When the length of a wire is doubled, then its resistance also gets doubled.
Reason (R): The resistance of a wire is directly proportional to its length.

Q 23. Assertion (A): Alloys are commonly used in electrical heating devices like electric iron and heater.
Reason (R): Resistivity of an alloy is generally higher than that of its constituent metals but the alloys have low melting points than their constituent metals. *(CBSE 2020)*

Q 24. Assertion (A): If ρ_1 and ρ_2 be the resistivity of the materials of two resistors of resistances R_1 and R_2 respectively and $R_1 > R_2$.

Reason (R): The resistance $R = \rho\frac{l}{A} \Rightarrow \rho_1 > \rho_2$ if $R_1 > R_2$.

Q 25. Assertion (A): At high temperatures, metal wires have a greater chance of short circuiting.
Reason (R): Both resistance and resistivity of a material vary with temperature. *(CBSE 2020)*

Q 26. Assertion (A): In a chain of bulbs, 50 bulbs are joined in series. One bulb is removed now and circuit is completed again. If the remaining 49 bulbs are again connected in series across the same supply, then light gets decreased in the room.
Reason (R): Net resistance of 49 bulbs will be less than 50 bulbs.

Q 27. Assertion (A): The 200 W bulbs glows with more brightness than 100 W bulbs.
Reason (R): A 100 W bulb has more resistance than a 200 W bulb.

Q 28. Assertion (A): Resistance of 50 W bulb is greater than that of 100 W.
Reason (R): Resistance of bulb is inversely proportional to rated power.

Answers

A	B	C	D
2	4	1	3

1. (d)

2. (b) Ammeter is connected in series and the voltmeter in parallel

3. (d) temperature

4. (b) diameter d of the wire

5. (c) increases

6. (a) 5 A
Given,
length of first conductor = l
Area of first conductor = A
and resistance of first conductor = R

$$\therefore \quad R = \frac{\rho l}{A}$$

Now, length of another conductor = 2.5 l
and resistance of conductor = 0.5 R

$$\therefore \quad A' = \rho\left(\frac{2.5l}{0.5R}\right)$$

$$= \rho \times 5 \times \left(\frac{l}{R}\right)$$

Thus, $A' = 5A$ $\quad \left[\because A = \frac{\rho l}{R}\right]$

7. (d) $R_2 > R_1 > R_3$

8. (b) 40 Ω
Given that,
$V = 4$ Volt
$I = 100\ mA = 100 \times 10^{-3}$ A

COMMON ERROR

Most of the students forget to convert 'mA' into 'A', which leads to wrong answer.

$$\therefore \quad R = \frac{V}{I}$$

$$= \frac{4}{100 \times 10^{-3}} = 40\ \Omega$$

9. (b) 0.06A
In series combination, current is same in every part of the circuit.

10. (a) 2 Ω
To get maximum resistance, connect all four resistor in series combination,
$\therefore$ Equivalent resistance, $R = R_1 + R_2 + R_3 + R_4$

$$= \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = 2\ \Omega$$

TiP

Students must remember that combining resistances in parallel reduces equivalent resistance whereas combining resistance in series increases equivalent resistance.

11. (d) 10 V
The potential difference across 3Ω resistance will be equal to the potential difference of 10 V.

TiP

In parallel combination of resistors, the potential difference across each resistor is same and equal to the total potential difference.

12. (b) 0.6 A

In parallel, potential difference across each resistor will remain same. So, current through 10 Ω resistor

$$I = \frac{V}{R} = \frac{6}{10} = 0.6 \text{ A}$$

13. (c) Brightness of bulb B will be more than that of A.

TiP

Bulbs would glow according to their wattage.

14. (a) two times

15. (b) 300%

According to Joule's law of heating,

$$H = I^2Rt$$

When current is increased to two times.

$$H' = (2I)^2Rt = 4I^2Rt$$

$$\% \text{ change in heat dissipated} = \left(\frac{H' - H}{H}\right) \times 100$$

$$= \frac{4I^2Rt - I^2Rt}{I^2Rt} \times 100$$

$$= \frac{3I^2Rt}{I^2Rt} \times 100$$

$$= 300\%$$

16. (d) Maximum in case (iii)

17. (d) increases heavily

18. (d) 135 W

Power = $VI = 270 \times 0.5 = 135$ W

19. (c) 5 A

20. (a) volt-ampere

21. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

22. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

23. (c) The element of electric iron and heater are made up of alloys having high melting point.

Hence, Assertion (A) is true but Reason (R) is false.

24. (c) ρ is the characteristic of the material of resistors. It does not depend on the length and cross-sectional area of resistors. But Resistance (R) depends on the length and the cross-sectional area of the resistor.

So, R_1 may be greater than R_2 even when $\rho_1 \leq \rho_2$.

25. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

26. (d) When one bulb is removed, the resistance is decreased, hence current flowing through each bulb is increased.

As, $H \propto I_2$, hence light get increased in the room.

27. (b) $$R = \frac{V^2}{P}, \text{ i.e., } R \propto \frac{1}{P}$$

i.e., higher is the wattage of a bulb, lesser is the resistance and so it will glow bright.

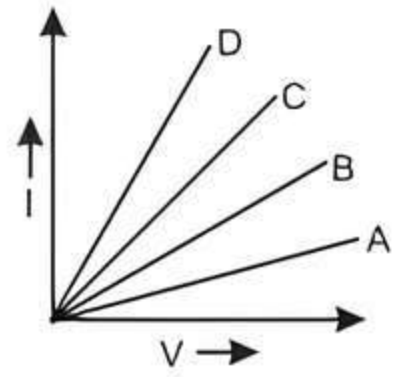
28. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

Ohm's law gives a relationship between current and potential difference. According to this law, at constant temperature, the current flowing through a conductor is directly proportional to the potential difference across its ends. The ratio of potential difference applied between the ends of a conductor and the current flowing through it is a constant quantity called resistance.

The following graph is obtained by a researcher while doing an experiment to study Ohm's law. The *I-V* graph for four conductors *A*, *B*, *C* and *D* having resistances R_A, R_B, R_C and R_D respectively are shown in the graph.



Read the above passage carefully and give the answer of the following questions:

Q 1. If all the conductors are of same length and same material, which is the thickest?

a. *C* b. *D* c. *A* d. *B*

Q 2. If all the conductors are of same thickness and of same material, which is the longest?

a. *B* b. *C* c. *A* d. *D*

Q 3. Which one of the following relations is true for these conductors?

a. $R_A > R_B > R_C > R_D$

b. $R_A = R_B < R_C < R_D$

c. $R_A < R_B < R_C < R_D$

d. $R_A = R_B = R_C = R_D$

Q 4. If conductors A and B are connected in series and *I-V* graph is plotted for the combination, its slope would be:

a. more than that of *A*

b. between *A* and *B*

c. more than that of *D*

d. less than that of *A*

Q 5. If conductors *C* and *D* are connected in parallel and *I-V* graph is plotted for the combination, its slope would be:

a. between *C* and *D*

b. lesser than that of *A*

c. more than that of *D*

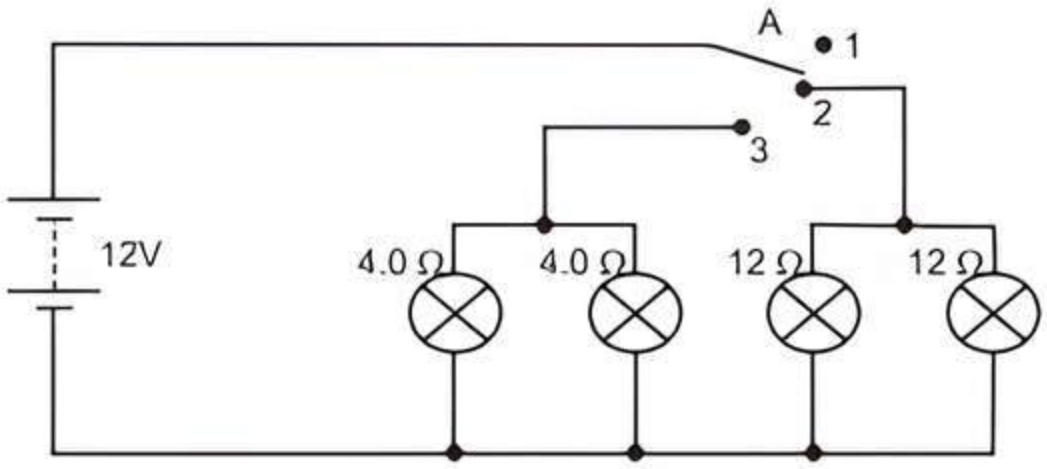
d. between *B* and *C*

Answers

1. (b) D
2. (c) A
3. (a) $R_A > R_B > R_C > R_D$
4. (d) less than that of A
5. (c) more than that of D

Case Study 2

Vinita and Ahmed demonstrated a circuit that operates the two headlights and the two sidelights of a car, in their school exhibition.



Based on their demonstrated circuit, answer the following questions:

Q 1. State what happens when switch A is connected to

(i) Position 2 (ii) Position 3

Q 2. Find the potential difference across each lamp when lit.

Q 3. Calculate the current:

(i) In each 12 Ω lamp when lit.

(ii) In each 4 Ω lamp when lit.

Or

Show, with calculations, which type of lamp, 4.0 Ω or 12 Ω, has the higher power. *(CBSE SQP 2023-24)*

Answers

1. (i) Only 12 Ω lamps will light up.
   (ii) Only 4 Ω lamps will light up.
2. 12 V for both sets of lamps as all of them are in parallel.
3. (i) Voltage across both 12 Ω lamps = 12 V.

   Using Ohm's law, $V = IR$

   $\Rightarrow \quad I = \frac{V}{R} = \frac{12}{12} = 1\ A.$

   (ii) Voltage across both 4 Ω lamps = 12 V.

   Using Ohm's law, $V = IR$

$\Rightarrow \quad I = \frac{V}{R} = \frac{12}{4} = 3\ A.$

Or

All lamps are in parallel and hence same V for all lamps.

Using, $P = V^2/R$

For 4 Ω lamps, $P = \frac{12 \times 12}{4} = 36\ W$

For 12 Ω lamps, $P = \frac{12 \times 12}{12} = 12\ W$

Hence, 4 Ω lamps will have higher power.

Case Study 3

When an electric current passes through a conductor (like a high resistance wire) the conductor becomes hot after some time and produces heat. This is called heating effect of electric current or joule heating or ohmic heating or resistive heating. The heating effect of electric current is widely used in our day-to-day life. The electric laundry iron, electric toaster, electric bulb, fuse and electric heater are some of the familiar devices based on Joule's heating.

Read the above passage carefully and give the answer of the following questions:

Q 1. Write the mathematical expression for Joule's law of heating.

Q 2. The following table gives the resistivity of three samples:

Sample	A	B	C
Resistivity	$1.6 \times 10^{-8}\ \Omega$ m	$5.2 \times 10^{-8}\ \Omega$ m	$100 \times 10^{-4}\ \Omega$ m

Which of them is suitable for heating elements of electrical appliances and why?

Q 3. Why does the cord of an electric heater not glow while the heating element does?

Q 4. State a difference between the wire used in the element of an electric heater and in a fuse wire.

Q 5. Tungsten is used almost exclusively for filaments of electric bulb. List two reasons.

Answers

1. The mathematical expression for Joule's law of heating is:

   Heat generated, $H = I^2Rt$

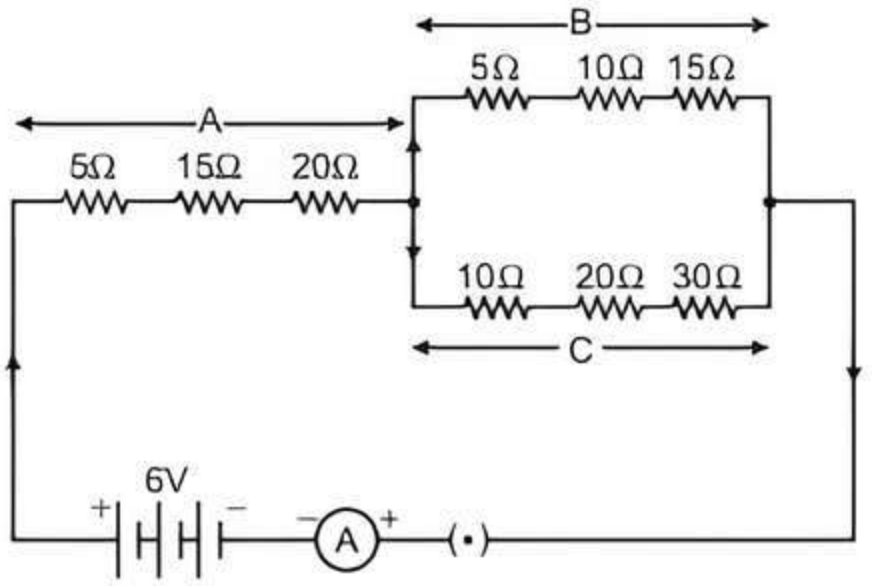
   where I is the amount of current flowing through the conductor, R is the resistance of conductor and t is the time for which the current has flown.
2. The resistivity of sample C is maximum so it is suitable for making heating elements of electrical appliances.
3. The cord of an electric heater is made up of copper with very low resistance whereas heating elements are made up of alloys which have very

high resistance. So, when current flows through the heating element, it becomes too hot and glows red due to heating effect of current.

4. The wire used in element of electric heater has high resistance and high melting point whereas a fuse wire has low resistance and low melting point.
5. Tungsten is used for making filaments of electric bulb because of the following reasons:
   (i) It has very high melting point
   (ii) It has high resistivity

Case Study 4

Study the following electric circuit in which the resistors are arranged in three arms *A*, *B* and *C*:



Study the above electric circuit carefully and give the answer of the following questions:

Q 1. Find the equivalent resistance of arm *C*.

Q 2. Calculate the equivalent resistance of the parallel combination of the arms *B* and *C*.

Q 3. (i) Determine the current that flows through the ammeter.

Or

(ii) Determine the current that flows in the ammeter when the arm *B* is withdrawn from the circuit.

(CBSE 2022 Term-2)

Answers

1. In arm *C*, 10 Ω, 20 Ω and 30 Ω are in series.

   Thus, the equivalent resistance,

   $R_C = 10 + 20 + 30 = 60\ \Omega$

2. From the given circuit, the equivalent resistance of parallel combination of arm *B* and *C*

$$\frac{1}{R_{BC}} = \frac{1}{(5+10+15)} + \frac{1}{(10+20+30)}$$

$$= \frac{1}{30} + \frac{1}{60}$$

$$\frac{1}{R_{BC}} = \frac{2+1}{60} = \frac{3}{60}$$

$$R_{BC} = \frac{60}{3} = 20\ \Omega$$

3. (i) From the given circuit, the equivalent resistance of arm *A* (R_A) is combined in series with R_{BC}.

   ∴ Total resistance of the circuit $R = R_A + R_{BC}$

   $= (5 + 15 + 20) + 20$

   $= 40 + 20 = 60\ \Omega$

   Thus, the current flowing through ammeter,

$$I = \frac{V}{R} = \frac{6}{60}$$

$$= \frac{1}{10} = 0.1\ \text{A}$$

   Or

   (ii) When the arm *B* is withdrawn from the circuit, the equivalent resistance,

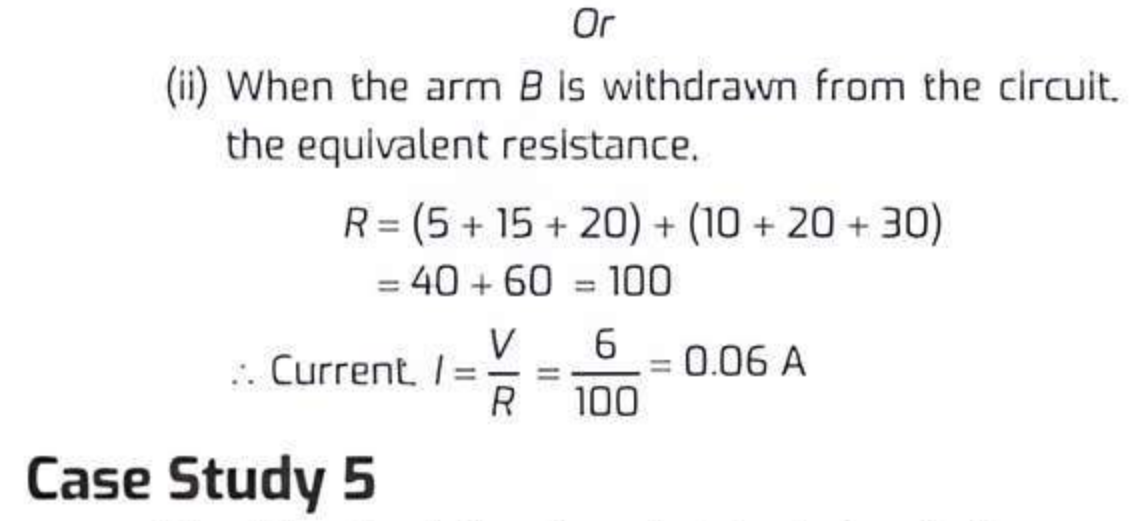
$$R = (5 + 15 + 20) + (10 + 20 + 30)$$

$$= 40 + 60 = 100$$

$$\therefore \text{Current } I = \frac{V}{R} = \frac{6}{100} = 0.06\ \text{A}$$

Case Study 5

Consider the following electrical circuit diagram in which nine identical resistors of 3 Ω each are connected as shown. The reading of the ammeter A_1 is 1 ampere.



Study the above electrical circuit carefully and give the answer of the following questions:

Q 1. What is the relationship between the readings of A_1 and A_3? Give reasons for your answer.

Q 2. What is the relationship between the readings of A_2 and A_3?

Q 3. Determine the reading of the voltmeter V_1.

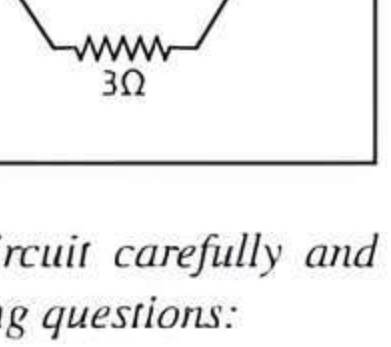
Or

Find the total resistance of the circuit. *(CBSE 2023)*

Answers

1. Reading of A_1 = Reading of A_3 because they are connected in series.
2. Reading of A_2 < Reading of A_3
3. $1/R_{eq} = \frac{1}{3} + \frac{1}{3}$

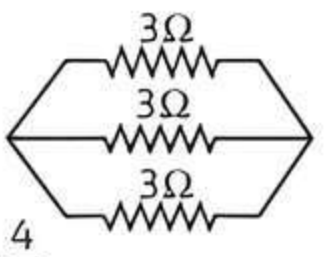
   or $R_{eq} = 3/2\ \Omega = 1.5\ \Omega$



$$V_1 = IR_{eq} = 1 \times \frac{3}{2} = 1.5\ \text{V}$$

Or

$$1/R'_{eq} = \frac{1}{3} \times \frac{1}{3} \times \frac{1}{3} = \frac{3}{3} = 1$$



or $R'_{eq} = 1\,\Omega$

Similarly, $1/R''_{eq} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{4}{3}$

or $R''_{eq} = \frac{3}{4}\Omega = 0.75\,\Omega$

Total resistance $= R'_{eq} + R'_{eq} + R''_{eq}$

$= 1.5\,\Omega + 1\,\Omega + 0.75\,\Omega$

$= 3.25\,\Omega$

Very Short Answer Type Questions

Q 1. Name and define the SI unit of current. *(CBSE 2019)*

Ans. The SI unit of current is ampere (A).

One ampere is defined as the flow of one coulomb of charge per second. *i.e.*, 1 A = 1 C/1 s.

Q 2. When is the potential difference between two points in a current carrying conductor said to be 1 volt? *(CBSE 2020)*

Ans. When one joule work is done to move a unit charge from one point to another, then the potential difference between two points is said to be one volt.

$$1\text{ volt} = \frac{1\text{ joule}}{1\text{ coulomb}} \quad \text{or} \quad 1\,V = \frac{1\,J}{1\,C}$$

Q 3. Write the function of voltmeter in an electric circuit. *(CBSE 2019)*

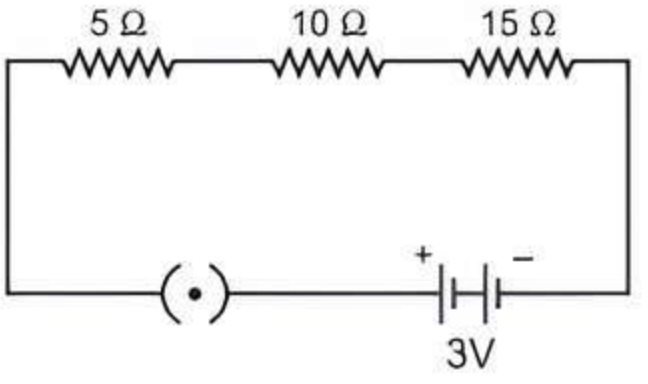
Ans. The function of voltmeter is to measure the potential difference across two points in a circuit.

Q 4. Should the resistance of a voltmeter be low or high? Give reason.

Ans. The resistance of a voltmeter should be high so that negligible current passes through it and it can measure the correct value.

Q 5. Draw a schematic diagram of an electric circuit consisting of a battery of two cells each of 1.5 V each, 5 Ω, three resistors of 10 Ω and 15 Ω respectively and a plug key, all connected in series.

Ans. Schematic diagram of electric circuit containing cells, key and three resistances.



Q 6. Define resistance. Give its SI unit. *(CBSE 2019)*

Ans. Resistance is the property of a conductor to resist the flow of current through it. Its SI unit is ohm.

Q 7. If the potential difference across the two ends of a conductor is 5 V and the current through it is 0.2 A, then what is the resistance of the conductor?

Sol. Given, $V = 5$ V and $I = 0.2$ A

We know that, $R = V/I = 5/0.2 = 25\,\Omega$

Thus, resistance of the conductor is 25 Ω.

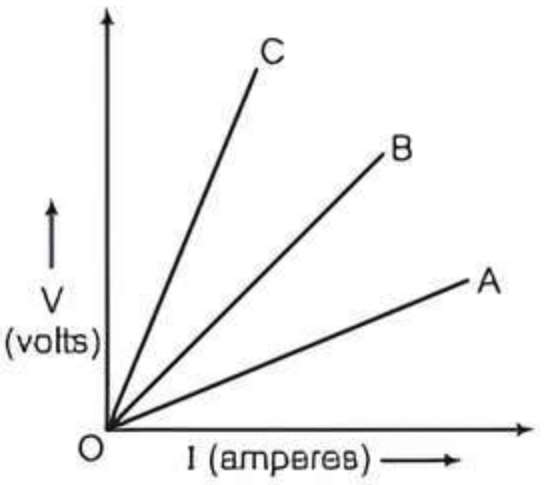
Q 8. Define the term electrical resistivity of a material.

Ans. We know that,

Resistivity, $\rho = R\frac{A}{l}$

If $A = 1$, $l = 1$ then $\rho = R$ *i.e.*, resistivity of a material is the resistance of a conductor of this material whose length and area of cross-section both are unity.

Q 9. Three *V-I* graphs are drawn individually for two resistors and their series combination. Out of *A*, *B*, and *C* which one represents the graph for series combination of the other two. Give reason.



Ans. More slope of *V-I* graph means more resistance. Slope of *C* is maximum, hence its resistance is maximum. So, *C* represents the graph for series combination of *A* and *B*.

Q 10. Why is parallel arrangement used in domestic wiring? *(NCERT EXEMPLAR)*

Ans. Parallel arrangement is used in domestic wiring so as to provide the same potential difference across each electrical appliance. Moreover if fault or short circuit occurs in any circuit, it will not result in the disconnection to other circuits.

Q 11. Why are the heating elements of electric toasters and electric irons made of an alloy rather than a pure metal? *(CBSE 2019)*

Ans. They are made of an alloy due to high resistivity of alloys rather than its constituting metals.

Q 12. How does use of a fuse wire protect electrical appliances? *(NCERT EXEMPLAR)*

Ans. Fuse wire protects electrical appliances by breaking the circuit (melting the fuse wire) when a current larger than the specified value flows in the circuit.

Q 13. Define 1 kilowatt hour. Represent it in terms of joules.

Ans. 1 kilowatt hour is the energy consumed when 1000 watt of power is used for 1 hour.

$$1\text{ kWh} = 1000\text{ W} \times 60 \times 60\text{ s} = 3.6 \times 10^6\text{ J}$$

Short Answer Type-I Questions

Q 1. List in a tabular form two differences between a voltmeter and an ammeter.

Ans.

S. No.	Basis of Difference	Voltmeter	Ammeter
(i)	Purpose	It is used to measure P.D. across two points in an electric circuit.	It is used to measure electric current in an electric circuit.

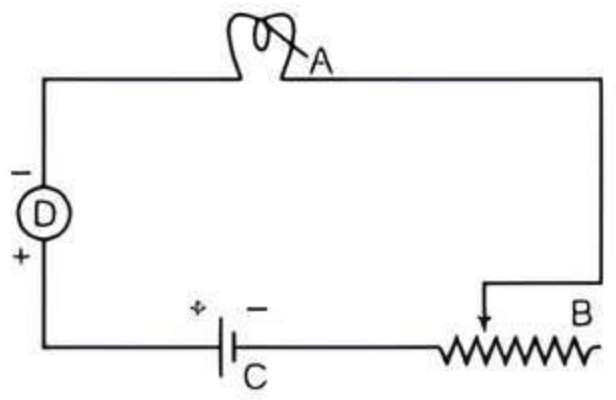
(ii)	Resistance	Its resistance is very high.	Its resistance is very low.
(iii)	Arrange-ment	An voltmeter is connected in parallel in an electric circuit.	An ammeter is connected in series in an electric circuit.

(Any two)

TiP

While understanding the concept of electric current and potential difference, lay stress on the definition and function of voltmeter and ammeter.

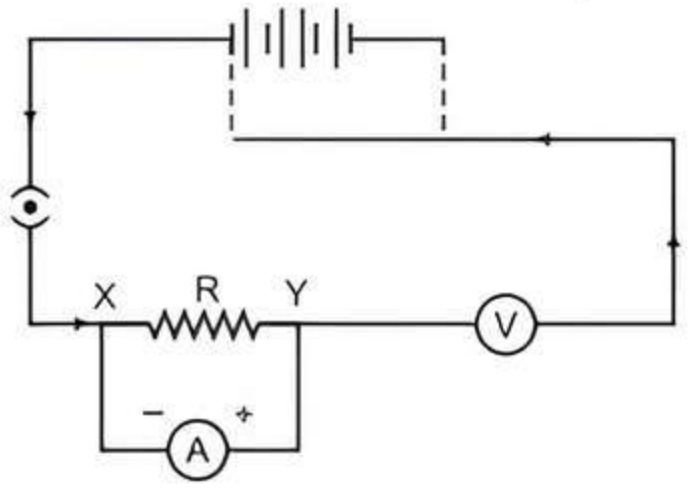
Q 2. Given below is a circuit showing current flowing in it. Identify each component *A*, *B*, *C*, *D* of this circuit:



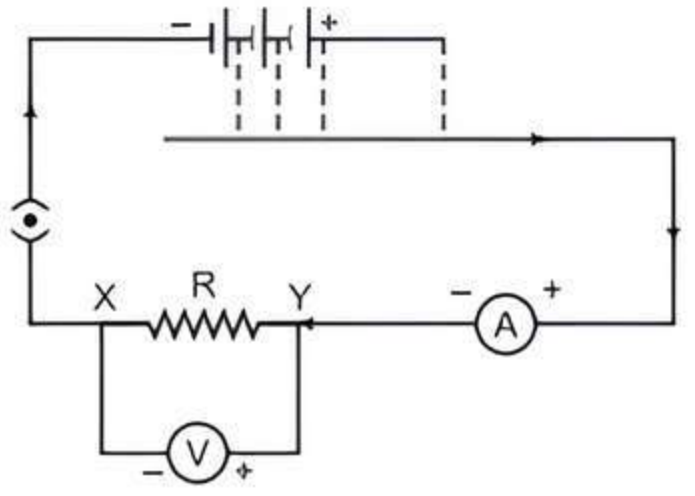
Ans. *A* is Electric Bulb; *B* is Rheostat or variable resistance; *C* is an electric cell and *D* is ammeter.

Q 3. A child has drawn the electric circuit to study Ohm's law as shown in figure. His teacher told that the circuit diagram needs correction. Study the circuit diagram and redraw it after making all corrections.

(NCERT EXEMPLAR)



Ans. The correct circuit diagram is:



COMMON ERROR

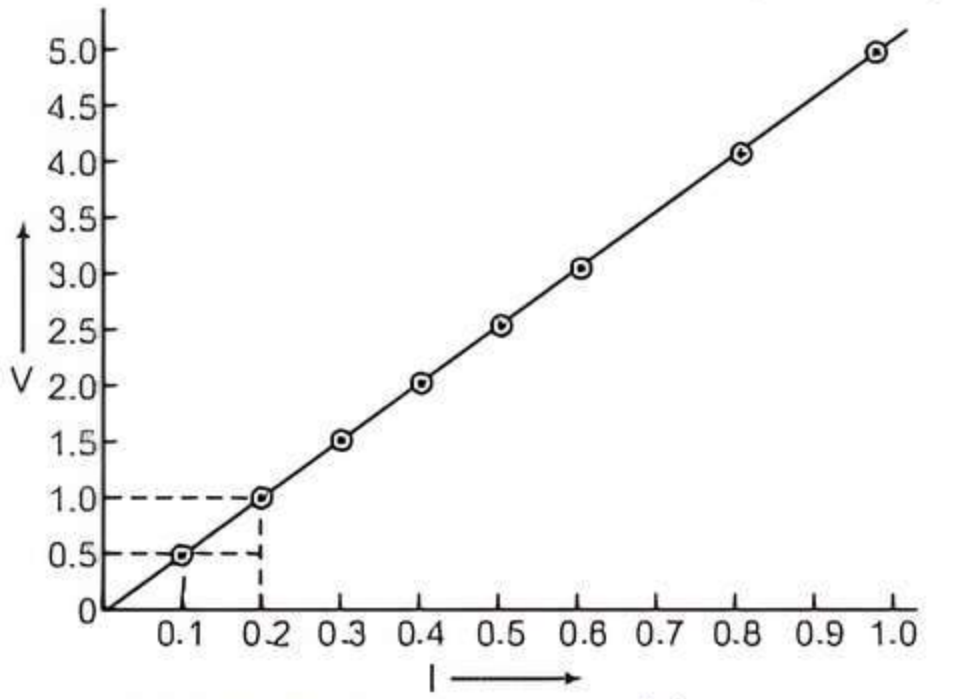
Many students fail to correct the direction of current in the given circuit.

Q 4. The values of current (*I*) flowing through a given resistor of resistance (*R*), for the corresponding values of potential difference (*V*) across the resistor are as given below:

V (volts)	0.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0
I (amperes)	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0

Plot a graph between current (*I*) and potential difference (*V*) and determine the resistance (*R*) of the resistor. *(CBSE 2018)*

Ans.

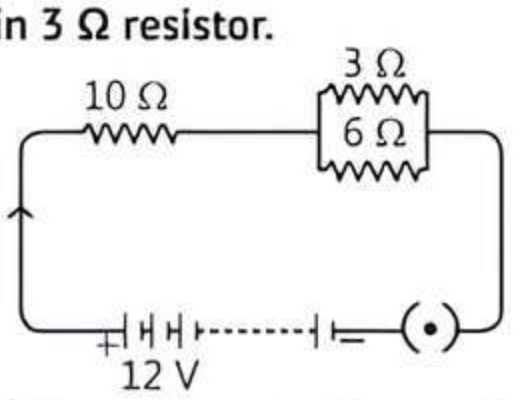


Slope of *V*-*I* graph gives resistance (*R*).

$$R = \frac{\Delta V}{\Delta I} = \frac{V_2 - V_1}{I_2 - I_1} = \frac{1.0 - 0.5}{0.2 - 0.1} = \frac{0.5}{0.1}$$

$\therefore \quad R = 5\ \Omega$

Q 5. Consider the circuit shown in the diagram. Find the current in 3 Ω resistor. *(CBSE 2011)*



Sol. 3 Ω and 6 Ω are connected in parallel.

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3} + \frac{1}{6} = \frac{1}{2}$$

$\therefore \quad R_p = 2\ \Omega$

R_p and 10 Ω are connected in series.

Hence, total amount of resistance, $R_s = R_p + 10$

$= 2 + 10 = 12\ \Omega$

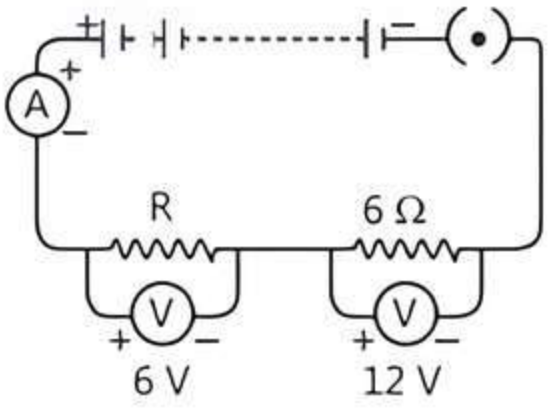
Total current in the circuit $I = \frac{V}{R_s} = \frac{12}{12} = 1\ A$

Now, voltage drop across the parallel connection

$= 1 \times 2 = 2V$

So, current across the 3Ω resistance $= \frac{V}{R} = \frac{2}{3}\ A$

Q 6. A circuit is shown in the diagram given below:



(i) Find the value of R.

(ii) Find the potential difference across the terminals of the battery.

Sol. (i) Potential difference across 6 Ω = 12 V

Hence, current through 6 Ω.

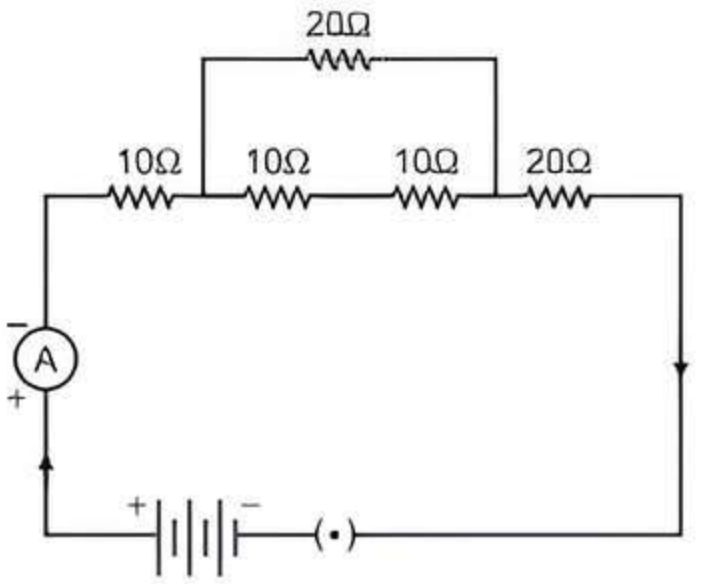
$$I = \frac{V}{R} = \frac{12}{6} = 2\,A$$

Since, R and 6 Ω are connected in series, therefore, the current through R will be 2 A. According to Ohm's law,

$$R = \frac{V}{I} = \frac{6}{2} = 3\,\Omega$$

(ii) Potential difference across the terminals of the battery $V = V_1 + V_2 = 6 + 12 = 18$ V

Q 7. Calculate the equivalent resistance of the following electric circuit: *(CBSE 2022 Term-2)*



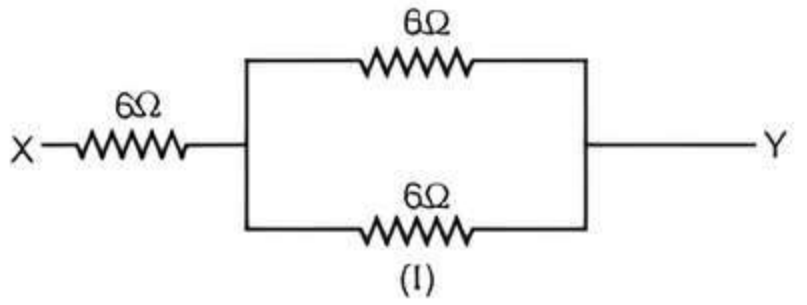
Sol. From the given electric circuit,

Equivalent resistance, $R_{eq} = 10 + \left(\frac{20 \times 20}{20 + 20}\right) + 20$

$$= 10 + \frac{400}{40} + 20$$

$$= 40\,\Omega$$

Q 8. A student shows two different ways in which three resistors of 6Ω each can be connected in a circuit. Show by calculation in which case is the equivalent resistance minimum.



Ans. Equivalent Resistance of Circuit (I):

$$R_I = 6 + \left(\frac{6 \times 6}{6 + 6}\right) = 6 + \frac{36}{12} = 6 + 3 = 9\,\Omega$$

Equivalent Resistance of Circuit (II):

$$R_{II} = \frac{6 \times 12}{6 + 12} = \frac{72}{18} = 4\,\Omega$$

Thus, circuit (II) has minimum resistance.

Q 9. A piece of wire of resistance R is cut into three equal parts. These parts are then connected in parallel. If the equivalent resistance of this parallel combination is R_1, what is the value of the ratio $R_1 : R$? *(CBSE SQP 2023-24)*

Sol. Resistance of each part $= \frac{R}{3}\Omega$ $(\because R \propto l)$

Equivalent resistance of parallel combination of these three parts $= R_1$

$$\Rightarrow \quad \frac{1}{R_1} = \frac{1}{(R/3)} + \frac{1}{(R/3)} + \frac{1}{(R/3)}$$

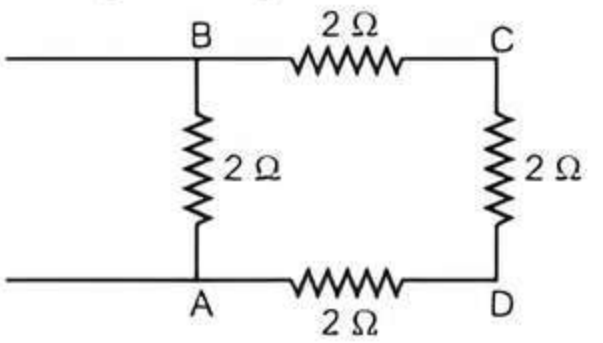
$$\Rightarrow \quad \frac{1}{R_1} = \frac{3}{R} + \frac{3}{R} + \frac{3}{R} = \frac{9}{R}$$

$$\Rightarrow \quad R_1 = \frac{R}{9}$$

or $$\frac{R_1}{R} = \frac{1}{9}$$

Hence, $R_1 : R = 1 : 9$.

Q 10. A student has four resistors of 2Ω each which are joined end to end to form a square ABCD. Calculate the equivalent resistance of the combination between any two adjacent corners.



Sol. Let us consider the equivalent resistance between A and B. Here, three resistances of 2 Ω are in series and this combination is connected in parallel to another resistor of 2 Ω.

Equivalent resistance of three series resistors

$= 2 + 2 + 2 = 6\,\Omega$

Required equivalent resistance $= \frac{1}{\frac{1}{6} + \frac{1}{2}} = \frac{1}{\frac{4}{6}} = 1.5\,\Omega$

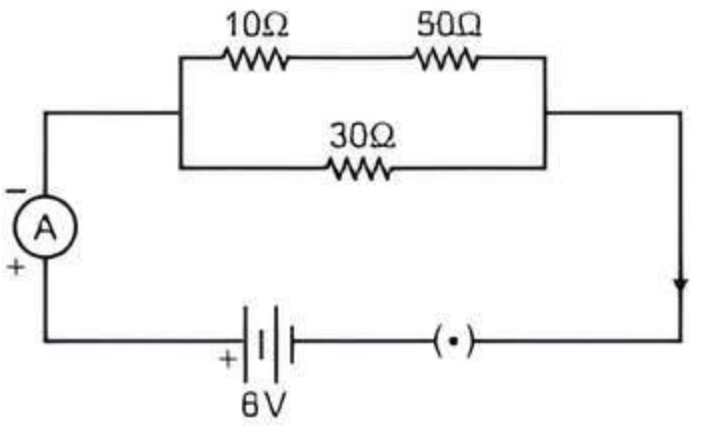
TiP

Clear your knowledge on finding total resistance in series and parallel circuit. It is advised to write the answer in SI unit.

Q 11. In the given circuit determine the value of:

(i) total resistance of the circuit

(ii) current flowing through the ammeter.



Sol. (i) From the given circuit. total resistance

$$= \frac{60 \times 30}{60 + 30} = \frac{1800}{90} = 20\ \Omega$$

(ii) From Ohm's law.

$$V = IR$$

$$I = \frac{V}{R} = \frac{6}{20} = 0.3\ \text{A}$$

Q 12. An electrical device of resistance *R* is connected across a source of voltage *V* and draws a current *I*. Derive an expression for power in terms of current and resistance. *(CBSE 2020)*

Ans. We know that. $V = W/Q$

$\Rightarrow$ $W = VQ$

Dividing both sides by '*t*'. we get

$W/t = VQ/t$

$\Rightarrow P = VI \quad (\because W/t = P \text{ and } Q/t = I)$

$\Rightarrow P = IR.I \ (\because V = IR) \quad \Rightarrow P = I^2R$

Q 13. Find the resistance of bulb rated as 100 W-250 V.

Sol. We have. $P = 100$ W.

$V = 250$ V

$$P = \frac{V^2}{R} \text{ or } R = \frac{V^2}{P}$$

$$R = \frac{(250)^2}{100} = \frac{250 \times 250}{100} = 625\ \Omega$$

Q 14. An electric heater rated 1100 W operates at 220 V. Calculate:

(i) its resistance and (ii) the current drawn by it.

(CBSE 2022 Term-2)

Sol. Given that.

$P = 1100$ W

$V = 220$ V

(I) As we know

$$P = \frac{V^2}{R} \quad \text{Or} \quad R = \frac{V^2}{P} = \frac{220 \times 220}{1100} = 44\ \Omega$$

(ii) From. $V = IR$

$$I = \frac{V}{R} = \frac{220}{44} = 5\ \text{A}$$

Short Answer Type-II Questions

Q 1. Define 1 V. Express it in terms of SI unit of work and charge. Calculate the amount of energy consumed in carrying a charge of 1 coulomb through a battery of 3 V.

Sol. When 1 joule of work is done in carrying 1 coulomb of charge. from infinity to a point in the electric field. then at that point. potential will be 1 volt.

Hence. $1\ \text{V} = 1\ \text{J/C}$

Potential difference between two points is

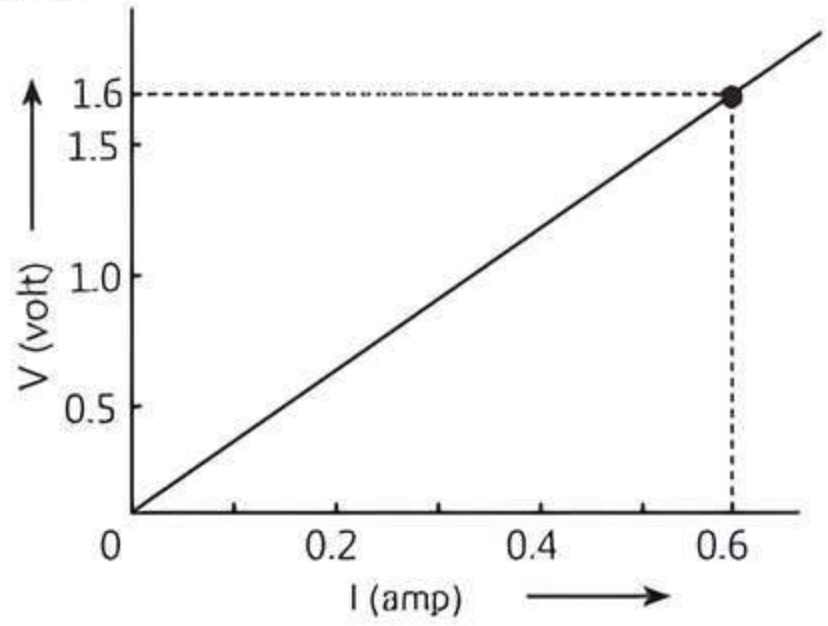
$$V = \frac{W}{q}$$

So. the amount of energy consumed.

$$W = q \times V = 1 \times 3 = 3\ \text{J}$$

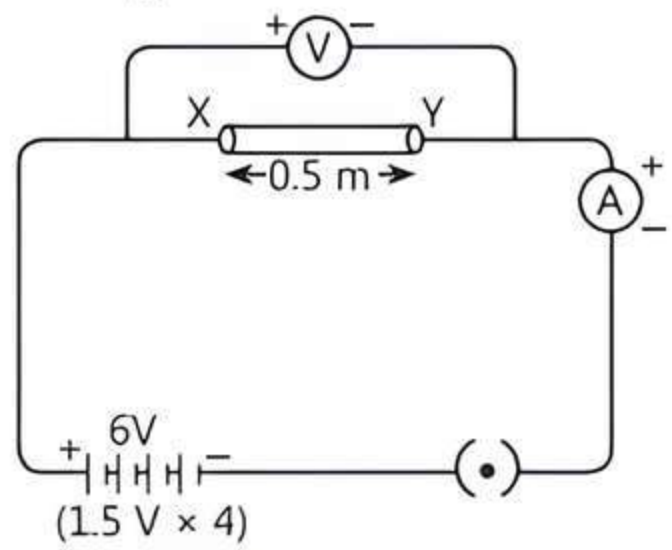
Q 2. (i) Draw a closed circuit diagram consisting of a 0.5 m long nichrome wire XY, an ammeter, a voltmeter, four cells of 1.5 V each and a plug-key.

(ii) Following graph was plotted between *V* and *I* values:



What would be the values of *V/I* ratios when the potential difference is 0.8 V, 1.2 V and 1.6 V respectively? What conclusion do you draw from these values? *(CBSE 2015)*

Ans. (i) **Circuit Diagram:**

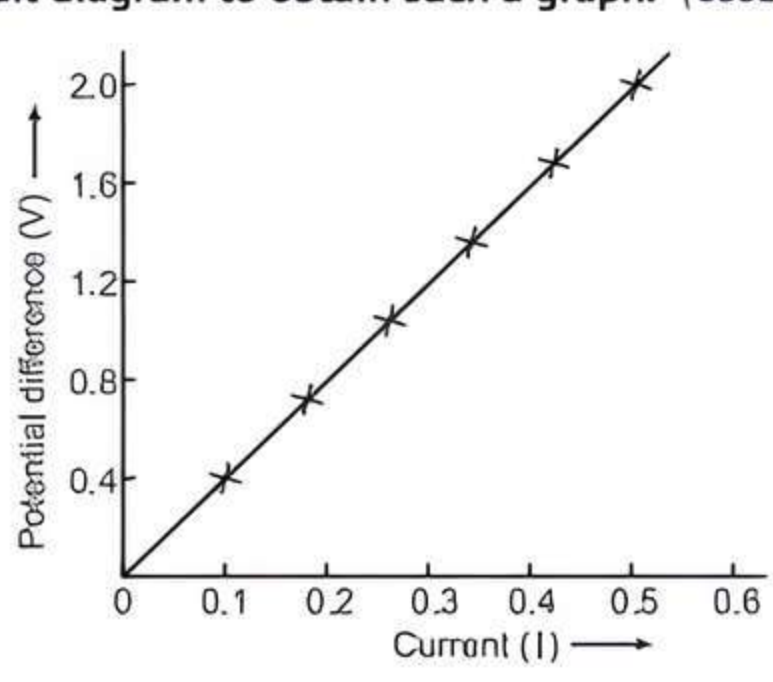


(ii) From the graph. when potential difference is 1.6 volt. the current is 0.6 A. thus

$$\frac{V}{I} = \frac{1.6}{0.6} = 2.67\ \Omega$$

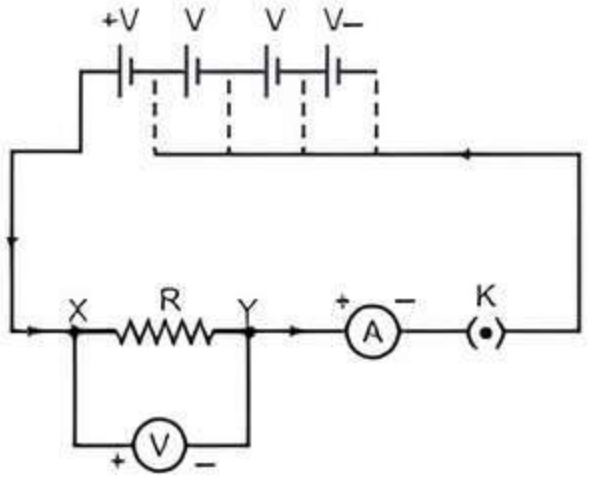
The straight line nature of the graph shows that the value of $\frac{V}{I}$ for all potential differences of 0.8 V. 1.2 V and 1.6V will be constant and equal to 2.67 Ω.

Q 3. A *V-I* graph for a nichrome wire is given below. What do you infer from this graph? Draw a labelled circuit diagram to obtain such a graph. *(CBSE 2020)*



Ans. The *V-I* graph of the nichrome wire is a straight line. So, we can conclude that current flowing through the wire is directly proportional to the potential difference across it. *i.e.*, $V \propto I$.

Circuit Diagram:



COMMON ERROR

Students fail to draw the electric circuit for studying Ohm's law.

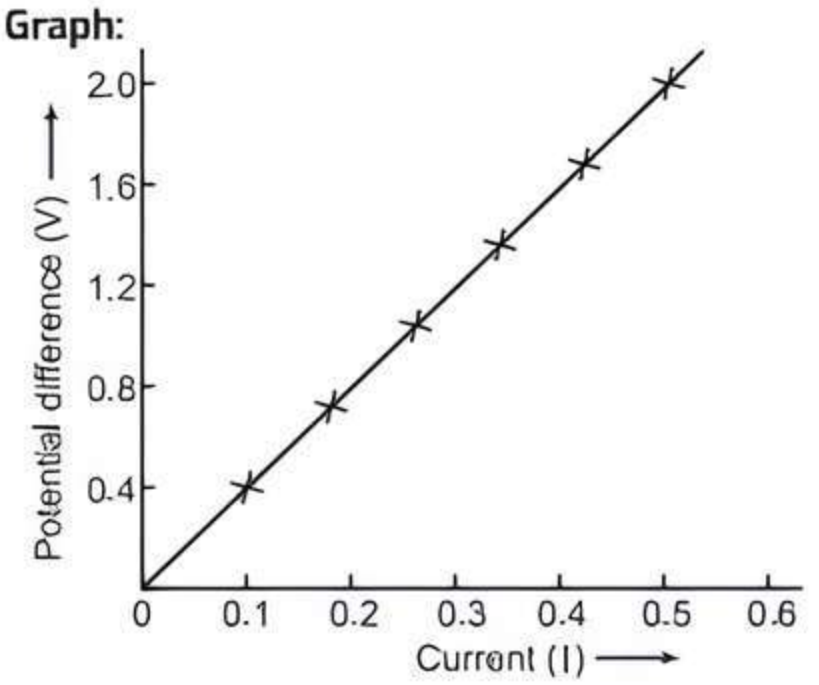
Q 4. (i) State the relation correlating the electric current flowing in a conductor and the voltage applied across it. Also draw a graph to show this relationship.

(ii) Find the resistance of a conductor if the electric current flowing through it is 0.35 A when the potential difference across it is 1.4 V. *(CBSE 2020)*

Ans. (i) The Ohm's law *i.e.*, potential difference across the ends of a conductor in an electric circuit is directly proportional to the current flowing through it, correlates electric current and voltage.

or $$\frac{V}{I} = \text{constant}$$

Graph:



(ii) Given, $I = 0.35$ A and $V = 1.4$ V

From Ohm's law,

$$R = \frac{V}{I} \Rightarrow R = \frac{1.4}{0.35} \Rightarrow \underline{R = 4\ \Omega}$$

Q 5. (i) List the factors on which the resistance of a conductor in the shape of a wire depends.

(ii) Why are metals good conductors of electricity whereas glass is a bad conductor of electricity? Give reason.

(iii) Why are alloys commonly used in electrical heating devices? Give reason. *(CBSE 2018)*

Ans. (i) Resistance of a conductor depends on the following factors:

(a) It is directly proportional to length (l) of the conductor.

$$R \propto l$$

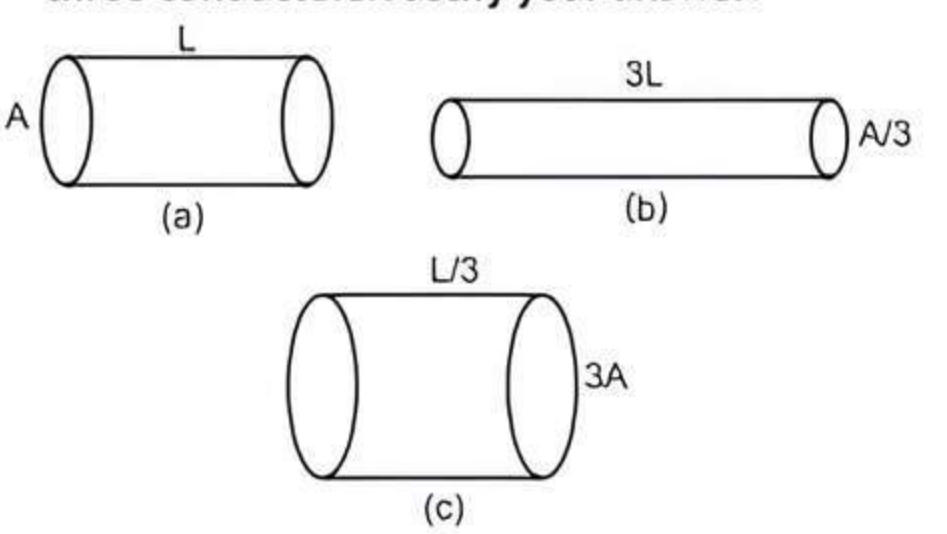
(b) It is inversely proportional to the area of cross-section of the conductor.

$$R \propto \frac{1}{A}$$

(ii) Metals are good conductors of electricity because they have free electrons to conduct electricity whereas glass does not have free electrons present in it hence it is a bad conductor of electricity.

(iii) Alloys are commonly used in electrical heating devices rather than pure metals as they have high resistivity as well as high melting point.

Q 6. The figure below shows three cylindrical copper conductors along with their face areas and lengths. Compare the resistance and the resistivity of the three conductors. Justify your answer:



Ans. In figure (a), the value of resistance,

$$R_a = \rho\frac{L}{A}$$

In figure (b), the value of resistance,

$$R_b = \rho\left(\frac{3L}{A/3}\right) = 9\left(\frac{\rho L}{A}\right) = 9R_a$$

In figure (c), the value of resistance,

$$R_c = \rho\left(\frac{L/3}{3A}\right) = \frac{1}{9}\left(\frac{\rho L}{A}\right) = \frac{1}{9}R_a$$

Hence, $R_b > R_a > R_c$

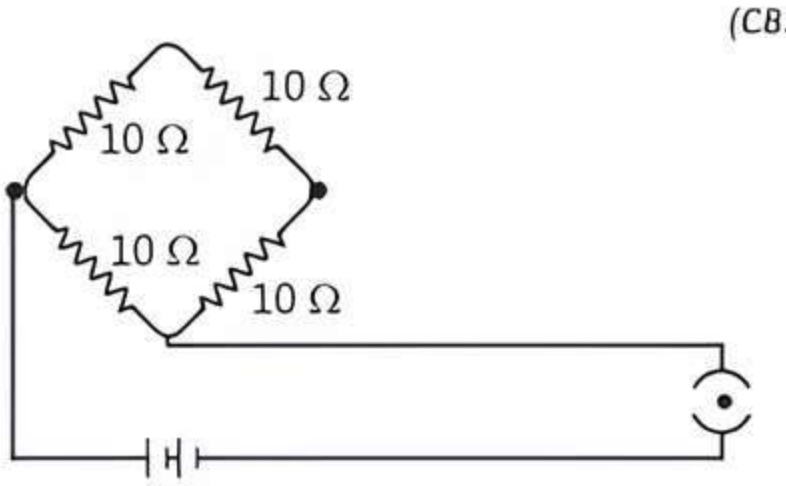
Also, $\underline{\rho_A = \rho_B = \rho_C}$ because all three conductors are of same material *i.e.*, copper.

COMMON ERROR

Many students commit errors in substituting the values in formulas. Some of them forget to answer the sub-part of this question i.e., compare the resistivity of three conductors.

Q 7. Find the current drawn from the battery by the network of four resistors as shown in the figure:

(CBSE 2015)



Sol. The given circuit shows a series combination of three 10 Ω resistors (let R_1, R_2, R_3) in parallel combination with one 10 Ω resistor (R_4). Hence, equivalent resistance of the given network is,

$$\frac{1}{R}=\frac{1}{R_4}+\frac{1}{R_1+R_2+R_3}$$

$$=\frac{1}{10}+\frac{1}{10+10+10}$$

$$=\frac{1}{10}+\frac{1}{30}=\frac{3+1}{30}=\frac{4}{30}$$

$$\Rightarrow \quad R=\frac{30}{4}=7.5\,\Omega$$

Now, the current drawn by the network,

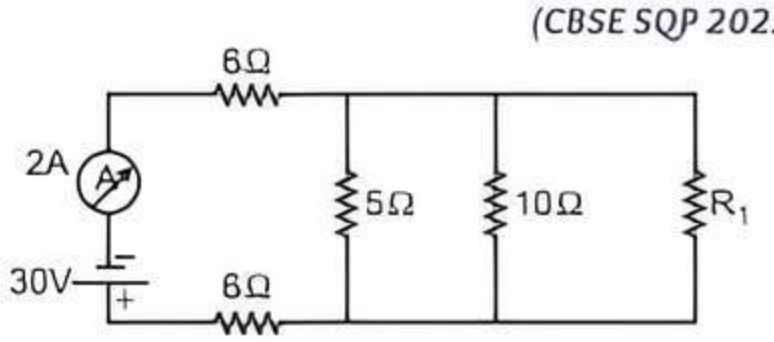
$$I=\frac{V}{R} \qquad (\because V=IR)$$

$$\Rightarrow \quad I=\frac{3}{7.5}=\underline{0.4\text{ A}}$$

Hence, the current drawn from the battery is 0.4 A.

Q 8. In the given circuit, if the current reading in the ammeter *A* is 2A, what would be the value of R_1?

(CBSE SQP 2022 Term-2)



Sol. In the given circuit, resistances

5 Ω, 10 Ω and R_1 Ω are in parallel

$$\therefore \text{ Resistance } \frac{1}{R}=\frac{1}{5}+\frac{1}{10}+\frac{1}{R_1}$$

$$=\frac{2R_1+R_1+10}{10R_1}=\frac{3R_1+10}{10R_1}$$

$$\Rightarrow \quad R=\frac{10R_1}{3R_1+10}$$

Now, $\frac{10R_1}{3R_1+10}$, 6 Ω and 6 Ω are in series

$$\therefore \text{ Equivalent resistance } R_{eq}=12+\frac{10R_1}{3R_1+10}$$

$$=\frac{36R_1+10R_1+120}{3R_1+10}$$

As we know, $R=\frac{V}{I}$

$$\therefore \quad \frac{36R_1+10R_1+120}{3R_1+10}=\frac{30}{2} \Rightarrow 46R_1+120=45R_1+150$$

$$\therefore \quad R_1=30\,\Omega$$

Q 9. Show how would you join three resistors, each of resistance 9 Ω so that the equivalent resistance of the combination is (i) 13.5 Ω and (ii) 6 Ω.?

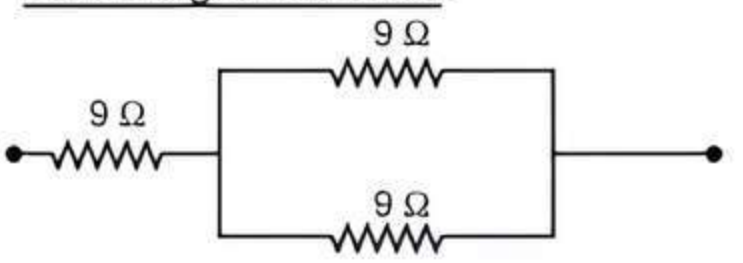
(CBSE 2018)

Ans.

TiP

Practice plenty of numericals based on finding the equivalent resistance of series and parallel circuits.

(i) To get equivalent resistance of 13.5 Ω, two 9 Ω resistors are first connected in parallel and then their combination is connected in series with the remaining 9 Ω resistor.

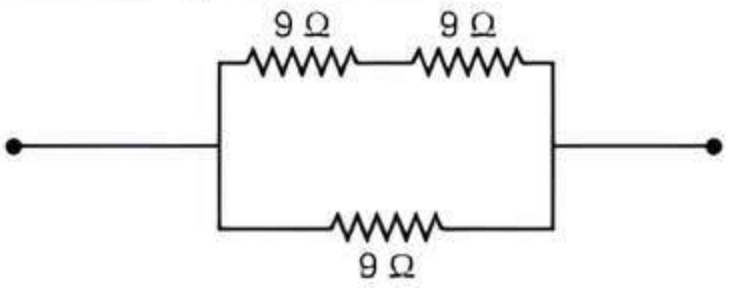


$$\frac{1}{R_p}=\frac{1}{9}+\frac{1}{9}=\frac{2}{9}$$

$$R_p=\frac{9}{2}=4.5\,\Omega$$

$$R=(9+4.5)\Omega=13.5\,\Omega$$

(ii) To get equivalent resistance of 6 Ω, two 9 Ω resistors are first connected in series and then this combination is connected in parallel with the remaining 9 Ω resistor.



$$R_s=9\,\Omega+9\,\Omega=18\,\Omega$$

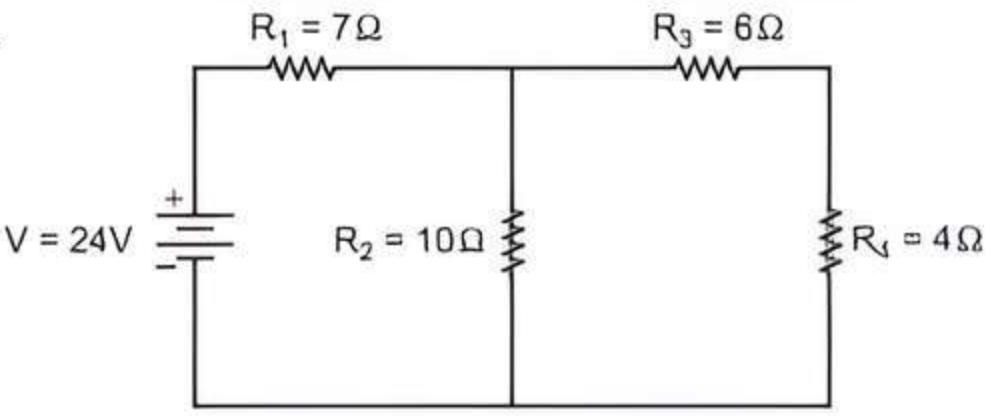
$$\frac{1}{R}=\frac{1}{18}+\frac{1}{9}=\frac{3}{18}$$

$$R=\frac{18}{3}=\underline{6\,\Omega}$$

COMMON ERR(!)R

Most students show the circuit diagram and write theory part while answering this question, but do not show calculations due to which their marks will be deducted.

Q 10.



Calculate the total resistance of the circuit and find the total current in the circuit. *(CBSE SQP 2022 Term-2)*

Sol. In the given circuit, resistance are combined in following way

$$R = [(R_4 + R_3) \,||\, R_2] + R_1$$

$$= [(4 + 6) \,||\, 10] + 7$$

$$= \left[\frac{10 \times 10}{10 + 10}\right] + 7$$

$$= \frac{100}{20} + 7 = 12\ \Omega$$

Thus, the total resistance of the circuit = 12 Ω

Now, total current, $I = \frac{V}{R} = \frac{24}{12} = 2$ A

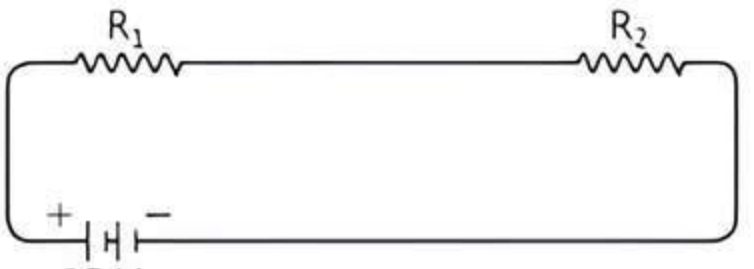
Q 11. Two resistors with resistance 10 Ω and 15 Ω are to be connected to a battery of emf 12 V so as to obtain:

(i) minimum current (ii) maximum current

Describe the mode of connecting the resistances in each case.

Calculate the strength of the total current in the circuit in each case. *(CBSE 2017)*

Ans. (i) The resistors are connected in series to obtain minimum current.



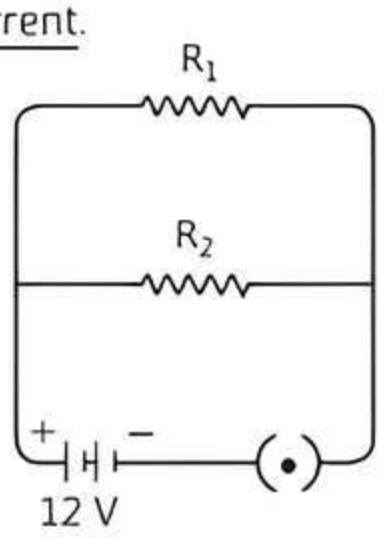
Given, $R_1 = 10\ \Omega$, $R_2 = 15\ \Omega$, $V = 12$ V, $I = ?$

$\therefore$ $R = R_1 + R_2 = 10 + 15 = 25\ \Omega$

According to Ohm's law, $V = IR$

$\Rightarrow$ $I = \frac{V}{R} = \frac{12}{25} = 0.48$ A

(ii) The resistors are connected in parallel to obtain maximum current.



Given: $R_1 = 10\ \Omega$, $R_2 = 15\ \Omega$, $V = 12$ V, $I = ?$

$\therefore$ $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R} = \frac{1}{10} + \frac{1}{15}$

$= \frac{3+2}{30} = \frac{5}{30}$

$\Rightarrow$ $\frac{1}{R} = \frac{1}{6}$ or $R = 6\ \Omega$

According to Ohm's law, $V = IR$

$\Rightarrow$ $I = \frac{V}{R} = \frac{12}{6} = 2$A

Q 12. (i) Write Joule's law of heating.

(ii) Compute the heat generated while transferring 96000 C of charge in two hours through a potential difference of 40 V. *(CBSE 2020)*

Ans. (I) **Joule's Law of Heating:** It states that the amount of heat produced in a conductor is:

(a) directly proportional to the square of current flowing through it. *i.e.*,

$$H \propto I^2$$

(b) directly proportional to the resistance of the conductor for a given current and time *i.e.*,

$$H \propto R$$

(c) directly proportional to the time for which current is flowing through it. *i.e.*,

$$H \propto t$$

Combining these, we get

$$H \propto I^2Rt$$

or

$$H = I^2Rt$$

(II) Given, $V = 40$ V, $Q = 96000$ C

Heat generated, $H = V.Q.$

$= 40 \times 96000 = 3.84 \times 10^6$ J

Q 13. (i) What is the meaning of electric power of an electrical device? Write its SI unit.

(ii) An electric kettle of 2 kW is used for 2h. Calculate the energy consumed in

(i) kilowatt hour and

(ii) joules *(CBSE 2022 Term-2)*

Ans. (i) Electric power is the rate at which electric energy is consumed by an electrical device in an electric circuit.

Its SI unit is Watt (W).

(ii) Given,

$P = 2$ kW

$t = 2$ h

We know that, Energy consumed, $E = P \times t$

(a) $E = 2 \times 2 = 4$ kWh

(b) $E = 4$ kWh $= 4 \times 3.6 \times 10^6$ J

$= 14.4 \times 10^6$ J

Long Answer Type Questions

Q 1. What is meant by electric current? Name and define its SI unit. In a conductor, electrons are flowing from B to A. What is the direction of conventional current? Give justification for your answer. *(CBSE 2015)*

A steady current of 1 ampere flows through a conductor. Calculate the number of electrons that flows through any section of the conductor in 1 second. (Charge on electron = -1.6×10^{-19} coulomb)

Ans. Electric Current: Electric current is the amount of charge 'q' flowing through a particular area of cross-section in unit time 't'.

Electric current $I = \frac{q}{t}$

SI unit of electric current is ampere.

One ampere is the current which flows when one coulomb of electric charge flows through a particular area of cross section of the conductor in one second *i.e.*, $1A = 1\,Cs^{-1}$.

The direction of conventional current is from A to B *i.e.*, opposite to the direction of flow of electrons.

Direction of flow of electrons gives the direction of electronic current. By convention, the direction of flow of positive charge is taken as the direction of conventional current.

We know that, $q = It = ne$

$\Rightarrow \quad It = ne$

$\Rightarrow \quad n = It/e$

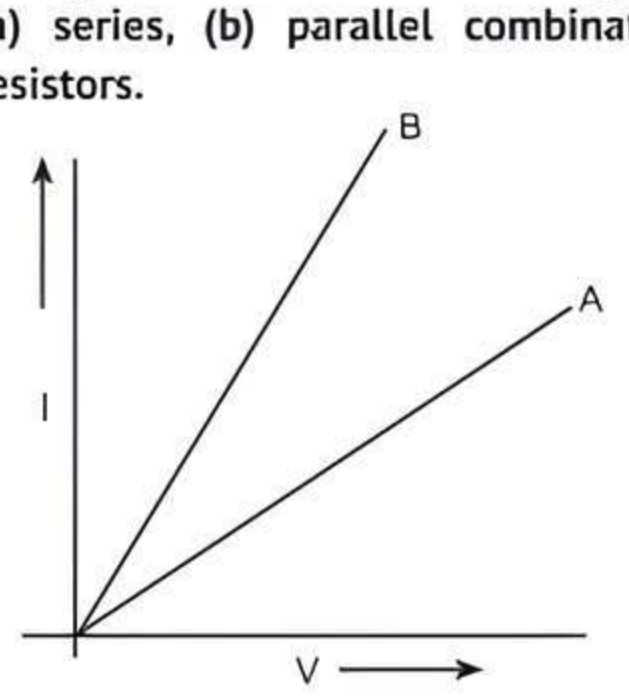
$\Rightarrow$ number of electrons.

$$n = \frac{1A \times 1s}{1.6 \times 10^{-19}C} = \frac{10^{19}}{1.6} = 6.25 \times 10^{18} \text{ electrons.}$$

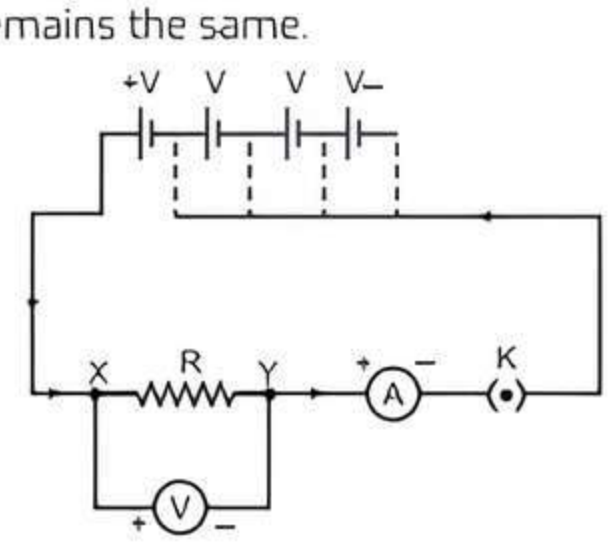
Q 2. (i) How is electric current related to the potential difference across the terminals of a conductor? Draw a labelled circuit diagram to verify this relationship.

(ii) Why should an ammeter have low resistance?

(iii) Two *V*-*I* graphs *A* and *B* for series and parallel combinations of two resistors are as shown. Giving reason state which graph shows (a) series, (b) parallel combination of the resistors. *(CBSE 2023)*



Ans. (i) The potential difference across the terminals of a conductor is directly proportional to the current flowing through it. provided its temperature remains the same.



TiP

Practice drawing circuit diagrams and remember the symbols of commonly used components in circuit diagrams.

(ii) An ammeter is used to measure the amount of current flowing in a circuit and is connected in series. Hence, its resistance adds to the total resistance of the circuit. If the resistance of the ammeter would be high, the total resistance would be high and this would decrease the amount of current flowing through the circuit. Hence, in order to measure the current appropriately, an ammeter has low resistance.

(iii) The slope of *I*-*V* graph gives (1/resistance). Since, straight line A is less steep, its resistance is more. We know that, in series combination, the equivalent resistance is more than in parallel combination. So, A represents series combination and B represents parallel combination of the resistors.

Q 3. (i) Write the relation between resistance and electrical resistivity of the material of a conductor in the shape of a cylinder of length *l* and area of cross-section *A*. Hence, derive the SI unit of electrical resistivity.

(ii) Resistance of a metal wire of length 5 m is 100 Ω. If the area of cross-section of the wire is $3 \times 10^{-7}\ m^2$, calculate the resistivity of the metal. *(CBSE 2019)*

Ans. (i) We know that, $R \propto l$ and $R \propto 1/A$

On combining, we get

$$R \propto \frac{l}{A}$$

or $$R = \rho\frac{l}{A}$$

or $$\rho = \frac{RA}{l} = \frac{\text{Ohm} \times m^2}{m}$$

$$= \text{Ohm} \times m$$

SI unit of electrical resistivity is Ohm-metre.

(ii) Given, $l = 5$ m, $R = 100\ \Omega$ and $A = 3 \times 10^{-7}\ m^2$

We know that,

$$\rho = \frac{RA}{l}$$

$$\rho = 100 \times 3 \times 10^{-7} / 5$$

$$\rho = 60 \times 10^{-7}\ \Omega\text{-m}$$

Q 4. (i) Find the ratio of resistances of two copper rods *X* and *Y* of lengths 30 cm and 10 cm respectively and having radii 2 cm and 1 cm respectively.

(ii) A current of 500 mA flows in a series circuit containing an electric lamp and a conductor of 10 Ω when connected to 6 V battery. Find the resistance of the electric lamp. *(CBSE 2020)*

Sol. (i) Given, $l_X = 30$ cm, $l_Y = 10$ cm.

$r_X = 2$ cm and $r_Y = 1$ cm

Using, $R = \rho\frac{l}{A}$

$$R_X = \rho\frac{l_X}{A_X} = \frac{30\ \rho}{\pi \times 2 \times 2} \qquad [\because A_X = \pi r_X^2]$$

$$= \rho\text{——} = \rho\frac{10}{\pi \times 1 \times 1} \qquad [\because A_Y = \pi r_Y^2]$$

$$\frac{R_X}{R_Y} = \frac{\rho.l_X}{A_x} \times \frac{A_Y}{\rho.l_Y}$$

$$= \frac{30}{\pi \times 2 \times 2} \times \frac{\pi \times 1 \times 1}{10}$$

$$\frac{R_X}{R_Y} = \frac{3}{4}$$

Hence, $R_X : R_Y = 3 : 4$

(ii) Here, $I = 500$ mA $= 0.5$ A:

Let Resistance of lamp be R_1

Given, Resistance of the conductor $(R_2) = 10\Omega$

and Potential difference $(V) = 6$ V

Net resistance of the circuit $= R = R_1 + R_2 = \frac{V}{I}$

$$\Rightarrow \quad R_1 + 10\ \Omega = \frac{6}{0.5}$$

$$\Rightarrow \quad R_1 + 10\ \Omega = 12\ \Omega$$

$$R_1 = (12 - 10)\ \Omega$$

$$= 2\ \Omega$$

COMMON ERR(!)R

Errors are commonly found in numericals. Students often forget to convert 'mA' to 'A'. This leads to incorrect answer and deduction of marks.

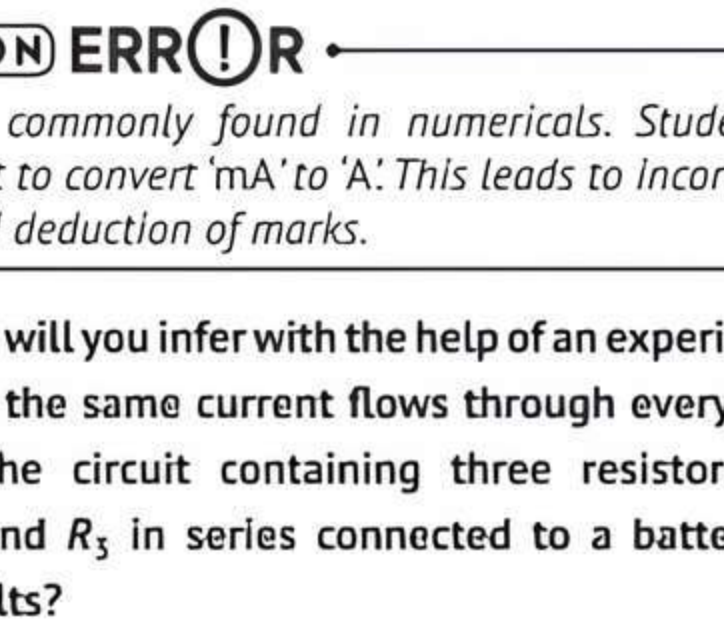
Q 5. (i) How will you infer with the help of an experiment that the same current flows through every part of the circuit containing three resistors R_1, R_2 and R_3 in series connected to a battery of V volts?

(ii) Study the following circuit and find out:

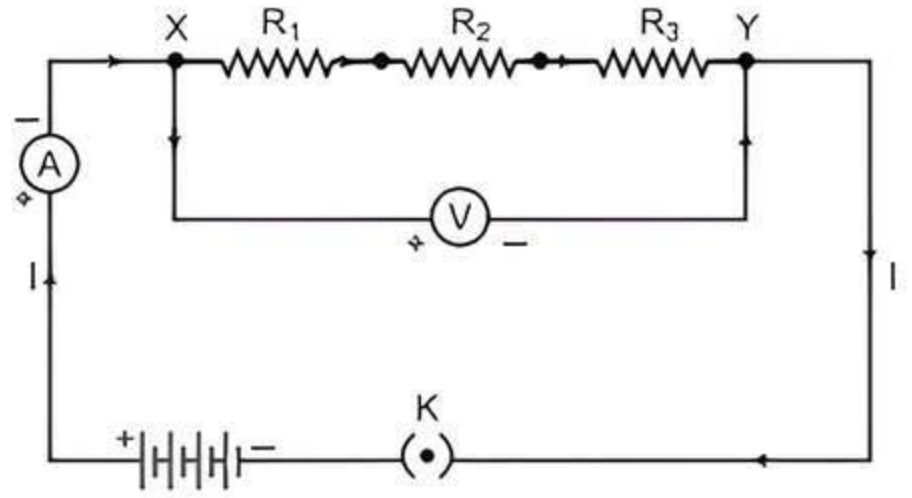
(a) Current in 12 Ω resistor.

(b) Difference in the readings of A_1 and A_2, if any.

(CBSE 2019)



Ans. (I)



(a) Three resistors R_1, R_2 and R_3 are connected in series.

(b) They are connected with a battery, an ammeter and a plug key as shown in figure.

(c) The ammeter reading is noted.

(d) Change the position of ammeter to anywhere in between the resistors.

(e) Note the ammeter reading each time.

(f) The value of the current in the ammeter is the same, independent of its position in the electric circuit.

It means that in a series combination of resistors, the current is the same in every part of the circuit or the same current flows through each resistor.

(II) 24 Ω and 24 Ω are connected in parallel.

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \left(\frac{1}{24}\right) + \left(\frac{1}{24}\right)$$

$R_p = 24/2 = 12\ \Omega$

Now, R_p and 12 Ω are connected in series.

Hence, total resistance $R_s = R_p + 12 = 12 + 12$

$= 24\ \Omega$

(a) Current passing through 12 Ω resistor.

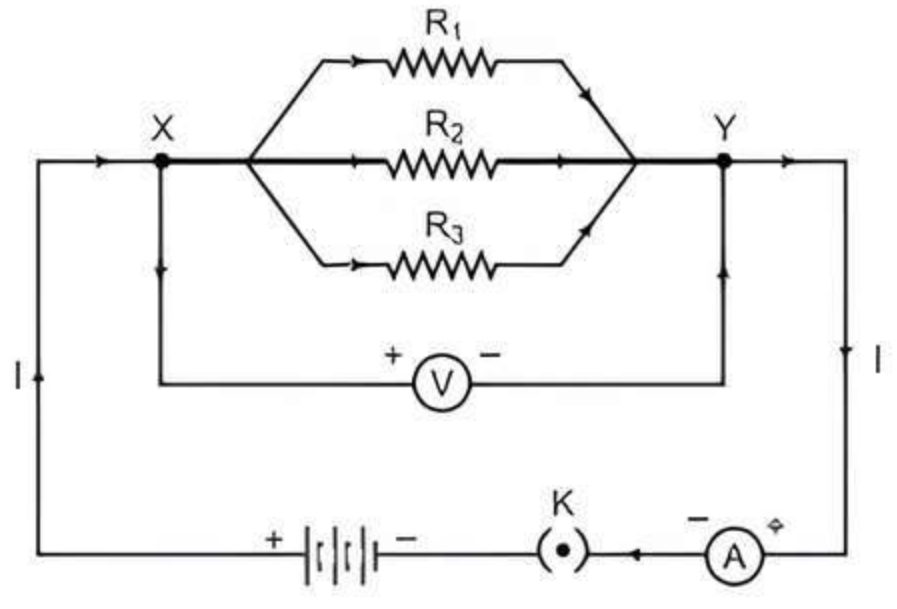
$I = V/R_s = 6/24 = 0.25$A

(b) There is no difference in the readings of A_1 and A_2 as they are connected in series.

Q 6. (i) With the help of a suitable circuit diagram, prove that the reciprocal of the equivalent resistance of a group of resistances joined in parallel is equal to the sum of the reciprocals of the individual resistances.

(ii) In an electric circuit, two resistors of 12 Ω each are joined in parallel to a 6 V battery. Find the current drawn from the battery. *(CBSE 2019)*

Ans. (i) Connect three resistors R_1, R_2 and R_3 in parallel between the point XY with a battery, a plug key and an ammeter in series shown in the figure.



Connect the voltmeter in parallel with these resistors between the terminals *X* and *Y*.

It is observed that the total current *I* is equal to the sum of the separate currents through each branch of the combination.

$$I = I_1 + I_2 + I_3$$

Let R_p be the equivalent resistance of the parallel combination of resistors. By applying Ohm's law to the parallel combination of resistors, we have

$$I = \frac{V}{R_p}$$

On applying Ohm's law to each resistor, we get

$$I_1 = \frac{V}{R_1};\ I_2 = \frac{V}{R_2};\ I_3 = \frac{V}{R_3}$$

Hence, $\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ or $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Thus, the reciprocal of the equivalent resistance of a group of resistances joined in parallel is equal to the sum of the reciprocals of the individual resistances.

TiP

The derivations of equivalent resistance of a group of resistances joined in series or parallel are important for the examination point of view.

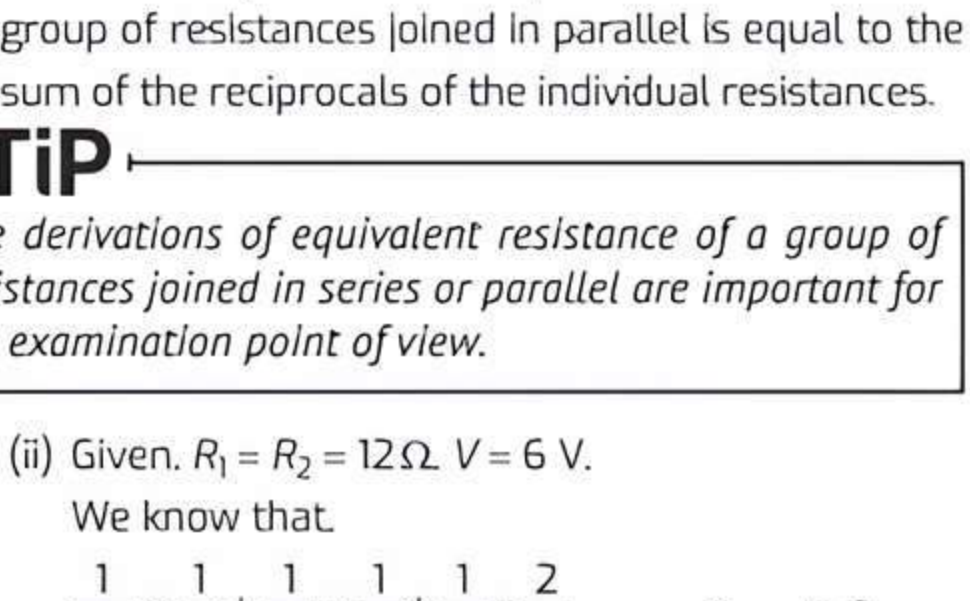
(ii) Given. $R_1 = R_2 = 12\,\Omega$, $V = 6$ V.

We know that

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{12} + \frac{1}{12} = \frac{2}{12} \quad \Rightarrow \quad R_{eq} = 6\,\Omega$$

$$\therefore \quad I = \frac{V}{R_{eq}} = \frac{6}{6} = 1\text{A}$$

Q 7.



The diagram above is a schematic diagram of a household circuit. The house shown in the above diagram has 5 usable spaces where electrical connections are made. For this house, the mains have a voltage of 220 V and the net current coming from the mains is 22 A.

(i) What is the mode of connection to all the spaces in the house from the mains?

(ii) The spaces 5 and 4 have the same resistance and spaces 3 and 2 have respective resistances of 20 Ω and 30 Ω. Space 1 has a resistance double that of space 5. What is the net resistance for space 5?

(iii) What is the current in space 3?

(iv) What should be placed between the main connection and the rest of the house's electrical appliances to save them from accidental high electric current? *(CBSE SQP 2022-23)*

Ans. (i) All spaces are connected in parallel.

(ii) Let resistance of space 5 and 4 be $R\Omega$ respectively.

Resistance of space 1 = $2R\,\Omega$

Resistance of space 2 = 30 Ω

Resistance of space 3 = 20 Ω

Current I = 22 A

V = 220 V

Total resistance $(R_{eq}) = V/I = \frac{220}{22} = 10\,\Omega$

$$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} = \frac{1}{R_{eq}}$$

$$\Rightarrow \quad \frac{1}{2R} + \frac{1}{30} + \frac{1}{20} + \frac{1}{R} + \frac{1}{R} = \frac{1}{R_{eq}}$$

$$\Rightarrow \quad \frac{30 + 2R + 3R + 60 + 60}{60R} = \frac{1}{R_{eq}}$$

$$\Rightarrow \quad \frac{150 + 5R}{60R} = \frac{1}{R_{eq}}$$

$$R_{eq} = \frac{60R}{150 + 5R} = 10$$

$$60R = 10\,(150 + 5R)$$

$$60R = 1500 + 50R$$

$$10R = 1500$$

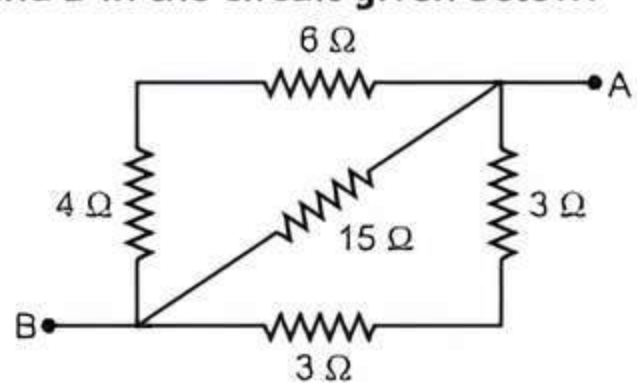
$$R = 150\,\Omega$$

(iii) Current in space 3 $= \frac{V}{R_3} = \frac{220}{20}$ A = 11 A

(iv) A fuse

Q 8. (i) List two disadvantages of using a series circuit in homes.

(ii) Calculate the effective resistance between *A* and *B* in the circuit given below: *(CBSE 2020)*



Ans. (i) Two disadvantages of using a series circuit at homes are as follows:

(a) Current is constant in series combination, so it is impractical to connect a bulb and an electric heater in series.

(b) If one electrical appliance stops working because of a serial circuit fault, then all devices will stop functioning.

(ii) 4 Ω and 6 Ω are connected in series, so, equivalent resistance $R_1 = 4 + 6 = 10\ \Omega$

Similarly, 3 Ω and 3 Ω are connected in series, so, equivalent resistance $R_2 = 3 + 3 = 6\ \Omega$ and $R_3 = 15\ \Omega$

R_1, R_2 and R_3 are connected in parallel.

So, effective resistance of the circuits is given by

$$\frac{1}{R} = \frac{1}{10\,\Omega} + \frac{1}{6\,\Omega} + \frac{1}{15\,\Omega}$$

$$= \frac{3+5+2}{30\,\Omega} = \frac{10}{30\,\Omega}$$

$$R = \frac{30}{10}\,\Omega = 3\,\Omega$$

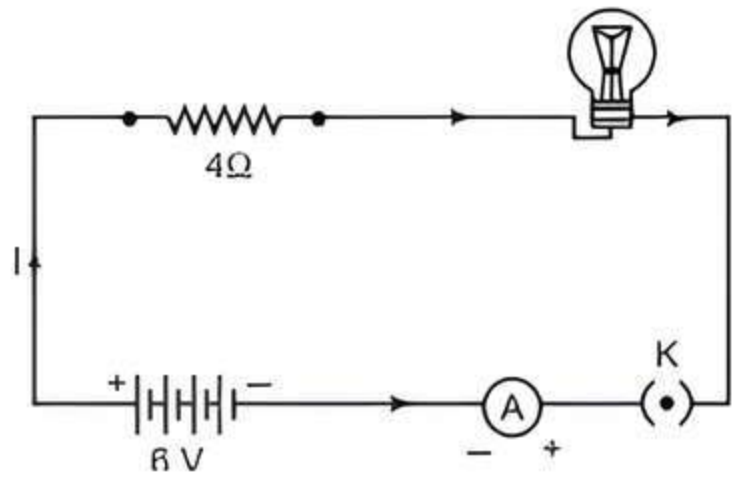
Q 9. An electric lamp of resistance 20 Ω and a conductor of resistance 4 Ω are connected to a 6 V battery as shown in the circuit. Calculate:

(i) the total resistance of the circuit,

(ii) the current through the circuit,

(iii) the potential difference across the (a) electric lamp and (b) conductor and

(iv) power of the lamp. *(CBSE 2019)*



Sol. Given, $R_1 = 20\ \Omega$, $R_2 = 4\ \Omega$ and $V = 6$ V

(i) Total resistance, $R = R_1 + R_2 = 20 + 4 = 24\ \Omega$

(ii) Current, $I = \frac{V}{R} = \frac{6}{24} = \frac{1}{4} = 0.25$ A

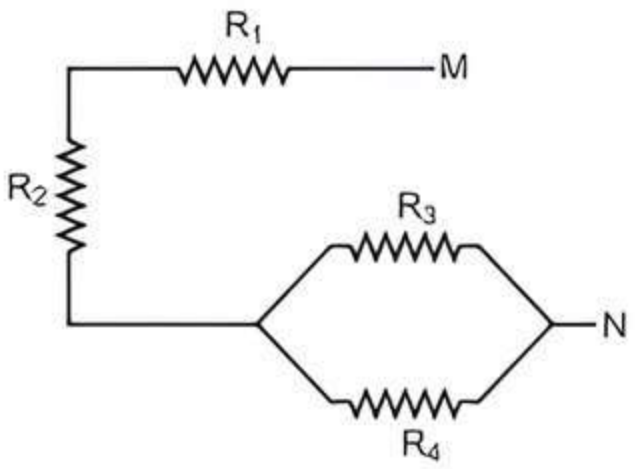
(iii) Potential difference across

(a) Electric lamp, $V_1 = IR_1 = 0.25 \times 20 = 5$ V

(b) Conductor, $V_2 = IR_2 = 0.25 \times 4 = 1$ V

(iv) Power of the lamp, $P = I^2R = (0.25)^2 \times 20 = 1.25$ W

Q 10. (i) For the combination of resistors shown in the following figure, find the equivalent resistance between *M* and *N*:



(ii) State Joule's law of heating.

(iii) Why we need a 5 A fuse for an electric iron which consumes 1 kW power at 220 V?

(iv) Why is it impracticable to connect an electric bulb and an electric heater in series? *(CBSE 2020)*

Sol. (I) R_3 and R_4 are in parallel connection.

$$\frac{1}{R'} = \frac{1}{R_3} + \frac{1}{R_4} = \frac{R_4 + R_3}{R_3R_4}$$

$$R' = \frac{R_3R_4}{R_4 + R_3}$$

Now R', R_1 and R_2 are in series connection, so

$$R_{eq} = R_1 + R_2 + \frac{R_3R_4}{R_4 + R_3}$$

(II) According to Joule's law of heating,

$$H \propto I^2$$

$$H \propto R$$

$$H \propto t$$

$$\therefore \quad \underline{H \propto I^2Rt}$$

or $\quad H = I^2Rt$.

where H is heat produced, I is current, R is resistance and t is time in seconds.

(III) Given, $P = 1$ kW $= 1000$ W, $V = 220$ V.

$\because \quad P = VI$

$I = \frac{P}{V} = \frac{1000}{220} = \frac{50}{11} = \underline{4.5\text{ A}}$, so 5 A fuse is needed.

(iv) In a series circuit, current is constant throughout the electric circuit. Thus, it is impracticable to connect an electric bulb and an electric heater in series, because they need current of widely different values to operate properly.

Q 11. (i) An electric bulb is rated at 200 V; 100 W. What is its resistance?

(ii) Calculate the energy consumed by 3 such bulbs if they glow continuously for 10 hours for complete month of November.

(iii) Calculate the total cost if the rate is ₹ 6.50 per unit. *(CBSE 2020)*

Sol. (i) Given, $V = 200$ V and $P = 100$ W

We know that, $P = \frac{V^2}{R}$

or $\quad R = \frac{V^2}{P} = \frac{(200)^2}{100\text{ W}} = \frac{40000}{100} = 400\ \Omega$

(ii) Electrical energy consumed, E = number of units × Power of each unit × time × total days

Here, $n = 3$, $P = 100$ W, $t = 10$ hours, Days $= 30$

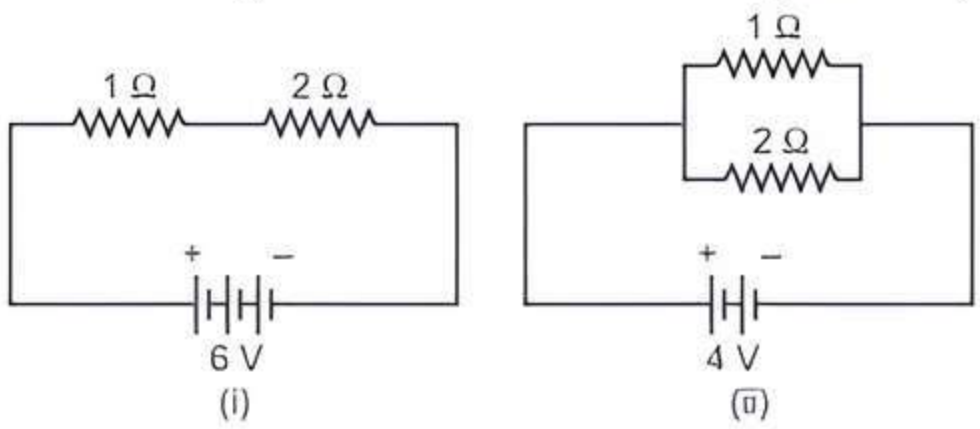
So, $\quad E = 3 \times 100\text{ W} \times 10\text{ h} \times 30 = 90{,}000\text{ Wh}$

$= 90$ kWh $= 90$ units

(iii) Total cost of electricity = Total unit of energy consumed × Cost per unit

$= 90$ units $\times$ 6.50 $=$ ₹ 585

Q 12. Compare the power used in 2 Ω resistor in each of the following circuits: *(CBSE 2019)*



Sol. (i) 1 Ω and 2 Ω resistors are connected in series.

The equivalent resistance of the circuit.

$R = 1 + 2$ or, $R = 3\ \Omega$

According to Ohm's law, $V = IR$, where, I = current through the circuit

$$\Rightarrow \quad I = \frac{6}{3} \quad \Rightarrow I = 2\ \text{A}$$

This current will flow through each component of the circuit because there is no division of current in series circuits. Hence, the current flowing through the 2 Ω resistor is 2 A.

We know that. $P = I^2R$

$$\Rightarrow \quad P = 2^2 \times 2$$

$$\Rightarrow \quad P = 8\ \text{W}$$

(ii) 1 Ω and 2 Ω resistors are connected in parallel.

The voltage across each component of a parallel circuit remains the same. Hence, the voltage across 2 Ω resistor will be 4 V.

Power consumed by 2 Ω resistor is given by.

$$P = V^2/R$$

$$\Rightarrow \quad P = \frac{4^2}{2} \quad \Rightarrow \quad P = 8\ \text{W}$$

Q 13. A bulb is rated 40 W; 220 V. Find the current drawn by it, when it is connected to a 220 V supply. Also find its resistance. If the given bulb is replaced by a bulb of rating 25 W; 220 V, will there be any change in the value of current and resistance? Justify your answer and determine the change. *(CBSE 2019)*

Sol. Given, $P = 40$ W and $V = 220$ V

We know that, $P = VI$

$$\Rightarrow \quad I = P/V = 40/220$$

$$\Rightarrow \quad I = 0.18\ \text{A}$$

We know that, $R = V^2/P$

$$\Rightarrow \quad R = (220 \times 220)/40$$

$$\Rightarrow \quad R = 1210\ \Omega$$

Now, $P = 25$ W and $V = 220$ V

We know that, $P = VI$

$$\Rightarrow \quad I = P/V = 25/220$$

$$\Rightarrow \quad I = 0.113\ \text{A}$$

We know that, $R = V^2/P$

$$\Rightarrow \quad R = (220 \times 220)/25$$

$$\Rightarrow \quad R = 1936\ \Omega$$

Yes, there is a change in the value of current and resistance.

Chapter Test

Multiple Choice Questions

Q 1. Two unequal resistances are connected in parallel. Which of the following statement is true?

a. Current is same in both
b. Current is higher in higher resistance
c. Voltage-drop is same across both
d. Voltage-drop is lower in lower resistance

Q 2. The relation between potential difference (V) and current (I) is:

a. $V \propto I^2$ b. $V \propto \frac{1}{I}$ c. $V^2 \propto I$ d. $V \propto I$

Q 3. If length of a conductor and it's radius, is increased twice, how the resistance will change?

a. Resistance will remain unchanged
b. Resistance increase twice
c. Resistance will become half
d. Resistance will increase 4 times

Q 4. How much energy is transferred when 10 A current flows through a resistor of 5 Ω for 30 minutes?

a. 0.25 kWh b. 1.2 kWh
c. 0.025 kWh d. 3.2 kWh

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): When a wire is stretched to three times of its length, its resistance becomes 9 times.
Reason (R): Resistance is directly proportional to length of wire.

Q 6. Assertion (A): Two resistance having value R each.

Their equivalent resistances is —.

Reason (R): Given resistance is connected in parallel.

Case Study Based Question

Q 7. The relationship between potential difference and current was first established by George Simon Ohm called Ohm's law. According to this law, the current through a metallic conductor is proportional to the potential difference applied between its ends, provided the temperature remain constant *i.e.*, $I \propto V$ or $V = IR$; where R is constant for the conductor and it is called resistance of the conductor. Although Ohm's law has been found valid over a large class of materials, there do exist materials and devices used in electric circuits, where the proportionality of V and I does not hold.

Read the above passage carefully and give the answer of the following questions:

(i) If both the potential difference and the resistance in a circuit are doubled then what will be the current in the circuit?

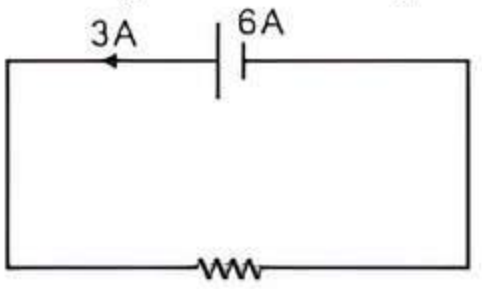
(ii) Draw *V-I* graph for a conductor.

(iii) What does the slope of *V-I* graph (*V* on *X*-axis and *I* on *Y*-axis) give?

(iv) When battery of 9 V is connected across a conductor and the current flows is 0.1 A. What will be the resistance?

Very Short Answer Type Questions

Q 8. How much charge flows through the resistor in 4s?



Q 9. Wire *A* and wire *B* has the following ratios

$$\frac{\text{length}(L_A)}{\text{length}(L_B)} = \frac{5}{18}, \quad \frac{\text{diameter}(D_A)}{\text{diameter}(D_B)} = \frac{2}{3}$$

and $$\frac{\text{resistivity}\,(\rho_A)}{\text{resistivity}\,(\rho_B)} = \frac{4}{9}$$

Calculate the ratio of the resistance of wire *A* to resistance of wire *B*.

Short Answer Type-I Questions

Q 10. What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series?

Q 11. Name and define the SI unit of resistance. Calculate the resistance of a metal wire of length 2m and area of cross section $1.55 \times 10^{-6} m^2$, if the resistivity of the metal be $2.8 \times 10^{-8}\ \Omega m$.

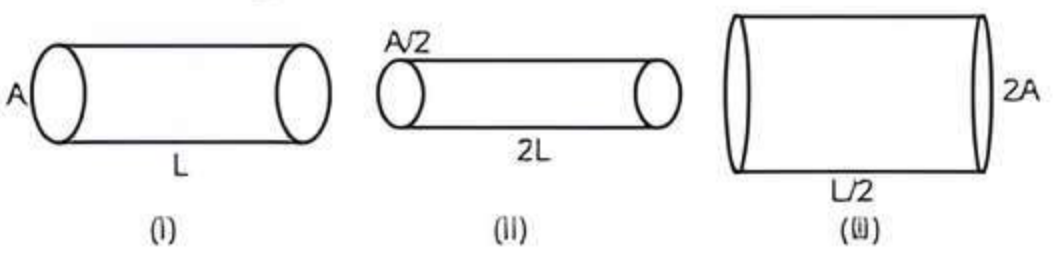
Q 12. Three incandescent bulbs of 100 W each are connected in series in an electric circuit. In another circuit, another set of three bulbs of the same wattage are connected in parallel to the same source.

(i) Will the bulbs in the two circuits glow with the same brightness? Justify your answer.

(ii) Now let one bulb in both the circuits get fused. Will the rest of the bulbs continue to glow in each circuit? Give reason.

Short Answer Type-II Questions

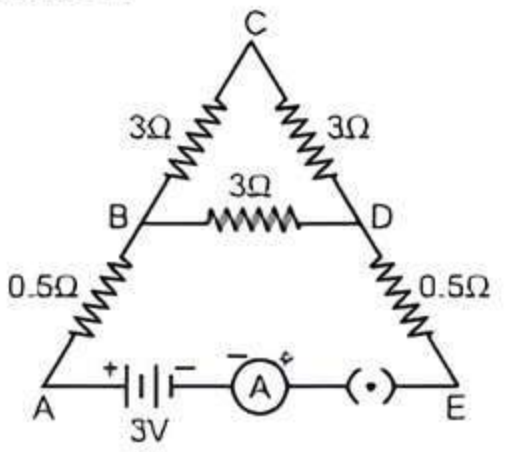
Q 13. The figure below shows three cylindrical copper conductors along with their face areas and lengths. Discuss in which geometrical shape, the resistance will be higher.



Q 14. Show four different ways in which three resistors of '*r*' Ohm each may be connected in a circuit. In which case is the equivalent resistance of the combination:

(i) Maximum (ii) Minimum

Q 15. Five resistors are connected in a circuit as shown. Find the ammeter reading when circuit is closed.

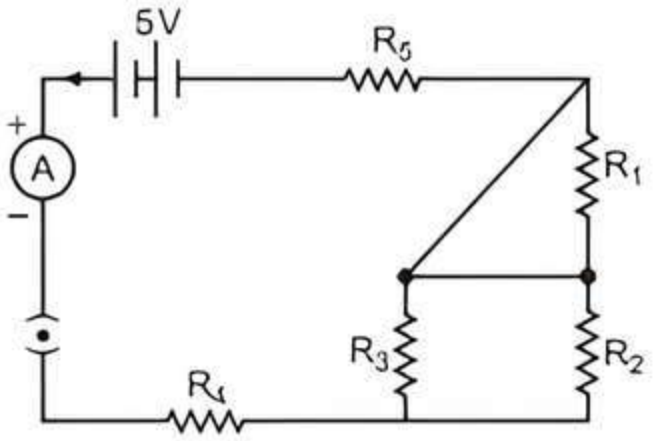


Long Answer Type Questions

Q 16. What is meant by electrical resistivity of a material? Derive its SI unit. Describe an experiment to study the factor on which the resistance of a conducting wire depends.

Q 17. (i) Deduce the expression for the equivalent resistance of the parallel combination of three resistors R_1, R_2 and R_3.

(ii) Consider the following electric circuit



(a) Which two resistors are connected in series?

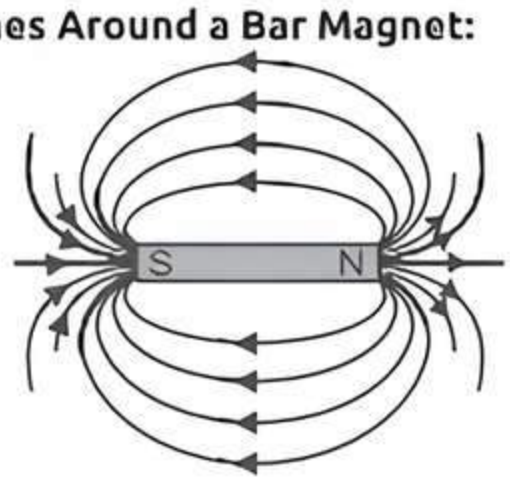
(b) Which two resistors are connected in parallel?

(c) If every resistors of the circuit is of 2 Ω, what current will flow in the circuit?

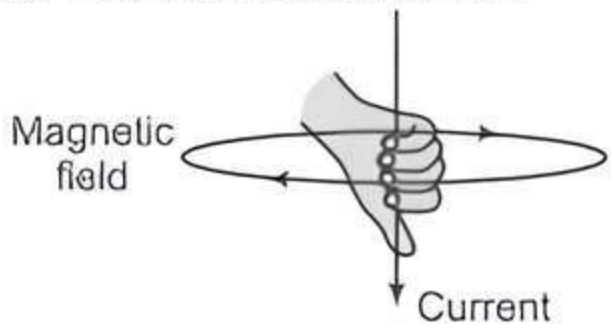
12 Magnetic Effects of Electric Current

Fastrack Revision

- **Magnet:** It is an object that attracts iron, cobalt and nickel particles. When it is suspended freely, it comes to rest in North-South direction.
- **Magnetic Field:** The space around a magnet in which the force of attraction or repulsion can be detected is called a magnetic field. It is a vector quantity. The SI unit of magnetic field is **tesla**.
- **Magnetic Field Lines:** These are curved paths along which the iron filings arrange themselves near a bar magnet due to the force acting on them in the magnetic field. They are also called magnetic field lines. These lines always emerge from N-pole of a magnet and merge at the S-pole of the magnet. Field lines never intersect each other.
- **Magnetic Lines Around a Bar Magnet:**

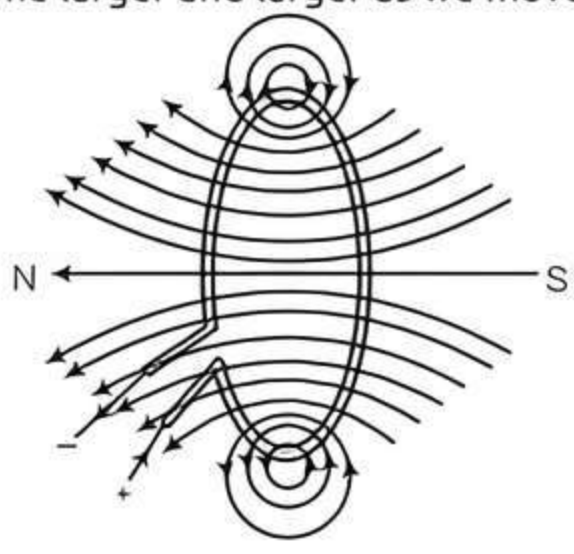


- **Right-Hand Thumb Rule:** This rule states that if a current carrying conductor is held in the right hand in such a way that thumb indicates the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor. It is also called Maxwell's right-hand thumb rule or Maxwell's corkscrew rule.

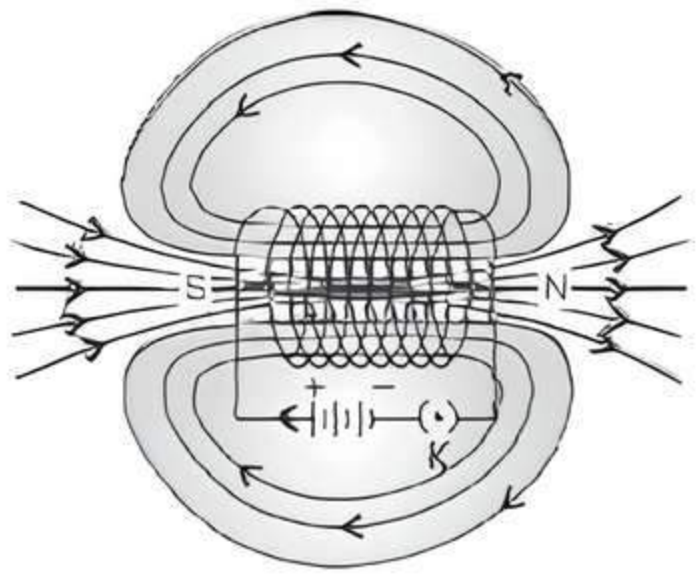


Magnetic field produced by a current carrying straight wire depends inversely on the distance from it and directly on the current passing through it.

- **Magnetic Field Produced by a Current Carrying Circular Loop:** It is represented by concentric circles at every point which become larger and larger as we move away.

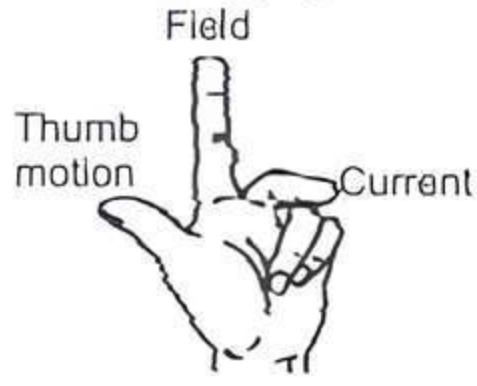


- **Solenoid:** It is a coil of many turns of insulated copper wire wrapped in the shape of a cylinder. The strength of magnetic field is proportional to the number of turns, magnitude of current and the nature of 'core material'.
- **Magnetic Field Lines through and Around a Current Carrying Solenoid**



- **Electromagnet:** An electromagnet refers to a magnetised solenoid which works on the principle of magnetic effect of current. The magnetic effect continues till the current flows through the solenoid. An electromagnet consists of a long insulated copper wire wound around a soft iron core. The electromagnets are used in electric motors, electric bells, loudspeakers, etc. Giant electromagnets are also used in cranes and lifts.
- **Force on a Current Carrying Conductor in Magnetic Field:** When a current carrying conductor is placed in a magnetic field, it experiences a magnetic force that depends on current flowing in the conductor, magnetic field, length of the conductor and direction of current and the direction of magnetic field.

  Force experienced by the conductor is maximum when the direction of current is at right angles to the direction of the magnetic field.
- **Fleming's Left-Hand Rule:** It is used to find out the direction of motion of a current carrying conductor when placed in a magnetic field. This rule is stated as, 'Stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular to each other.



If the first finger points in the direction of magnetic field and the second finger in the direction of current, then thumb will point in the direction of motion or the force acting on the conductor'.

MNEMONICS

Concept: *Fleming's Left-Hand Rule*

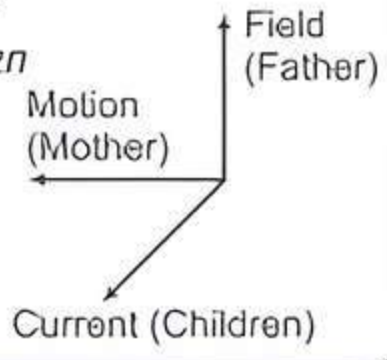
Mnemonics: ***F****ather,* ***M****other,* ***C****hildren*

Interpretation:

F – Field

M – Motion

C – Current



- **Direct Current (DC):** A current that always flows in the same direction through an electrical device is called a direct current.
- **Alternating Current (AC):** An electric current that reverses its direction periodically is called an alternating current. The frequency of AC in the Indian power supply is 50 HZ.

  Advantage of AC over DC: AC can be transmitted over long distances without much loss of energy.
- **Domestic Electric Circuits**
  (i) The electricity supplied to our houses by the electricity board is Alternating Current (AC) at 220 V and 500 Hz frequency. Each home is fitted with two different supplies, *viz.*, 5 A and 15 A. The 5 A supply (called domestic light) is used for bulbs, fans, TVs, etc., and the 15 A supply (called domestic power) is used for heaters, coolers, air conditioners, geysers, etc.

  (ii) We connect all the domestic electrical circuits in parallel because:
  (a) When two or more appliances are used at the same time, each appliance will be able to draw current as per the requirement.
  (b) When distribution circuits are in parallel, then each circuit operates separately. So, if one of the distribution circuits gets overloaded, only the fuse in that circuit will be blown off.

  (iii) Most of the electrical appliances are connected to the source of electricity by a three-core flexible cable containing live, neutral and earth.
- **Overloading:** The overheating of electrical wiring in any circuit, due to the flow of large current through it, is called overloading of the electrical circuit.
- **Electric Fuse:** A fuse is a piece of thin wire made up of a material having a low melting point and high resistance. Fuse wire is made from an alloy of lead and tin. Fuse is always connected in the live wire and in series with electrical circuit, to protect it from overloading or short-circuiting.
- **Earthing of Electrical Appliances:** Connecting the metallic body of an electrical appliance to a metal plate deep in the earth by the earth wire is called the **earthing of an electrical appliance**. Earth wire is used for safety measure to ensure that any leakage of current in a metallic body does not give any serious shock to a user.

Practice Exercise

Multiple Choice Questions

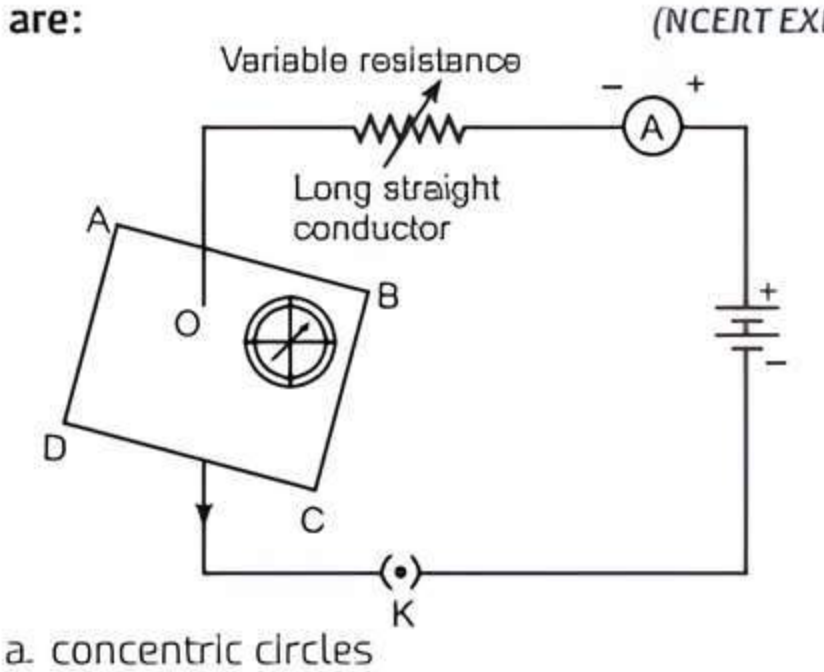
Q 1. Magnetic field is produced by the flow of current in a straight wire. The phenomenon was discovered by:

a. Faraday b. Fleming c. Maxwell d. Oersted

Q 2. By which instrument, the presence of magnetic field be determined?

a. Magnetic needle b. Ammeter
c. Galvanometer d. Voltmeter

Q 3. If the key in the arrangement is taken out (the circuit is made open) and magnetic field lines are drawn over the horizontal plane *ABCD*, the lines are: *(NCERT EXEMPLAR)*



a. concentric circles
b. elliptical in shape
c. straight lines parallel to each other
d. concentric circles near the point O but of elliptical shapes as we go away from it

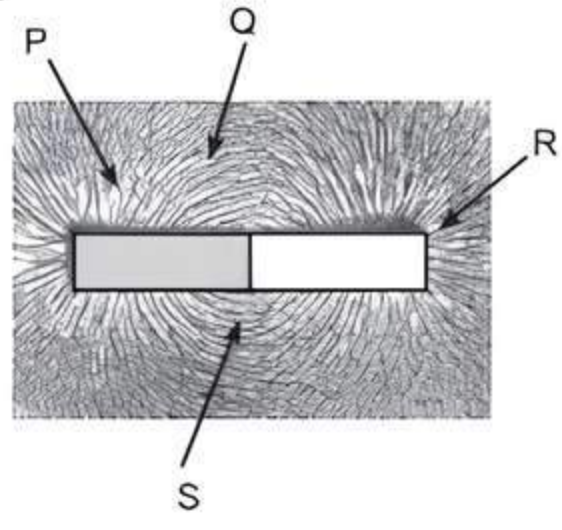
Q 4. Choose the incorrect statement from the following regarding magnetic lines of field. *(NCERT EXEMPLAR)*

a. The direction of magnetic field at a point is taken to be the direction in which the north pole of a magnetic compass needle points
b. Magnetic field lines are closed curves
c. If magnetic field lines are parallel and equidistant. they represent zero field strength
d. Relative strength of magnetic field is shown by the degree of closeness of the field lines

Q 5. Two magnetic field lines:

a. intersect at neutral point
b. never intersect each other
c. intersect near north pole or south pole
d. intersect at the mid point of the magnet

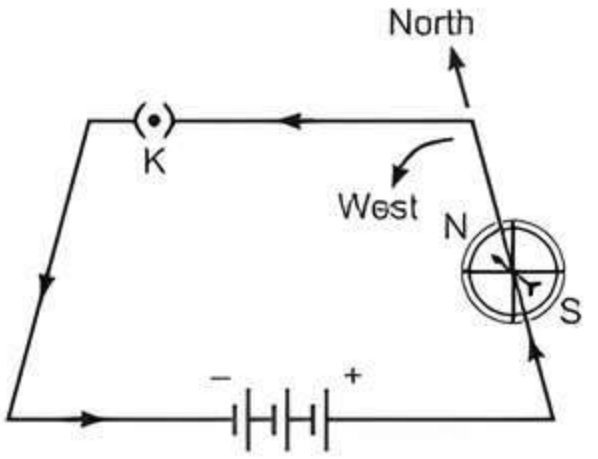
Q 6. A student places some iron filings around a magnet. The iron filings arrange themselves as shown in image:



The student labelled four different regions around the magnet. Where would the magnetic field be the strongest?

a. *P* b. *Q* c. *R* d. *S*

Q 7. A thick copper wire carries current due north placed parallel to and over a compass needle as shown in figure:



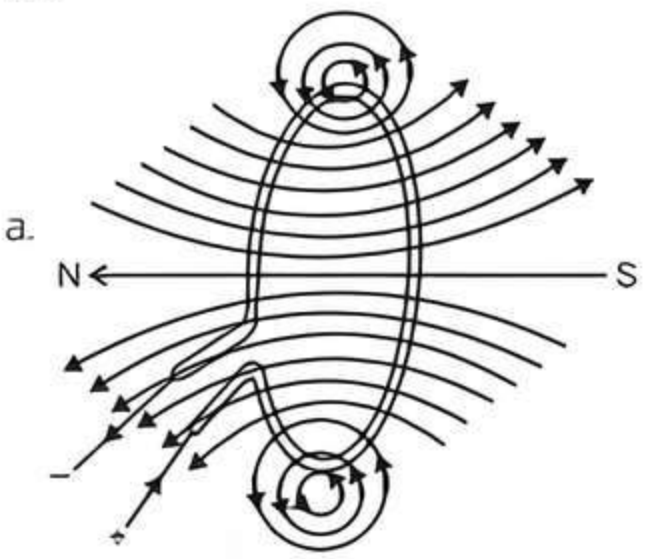
If the direction of current is changed from north to south, the needle will turn towards:

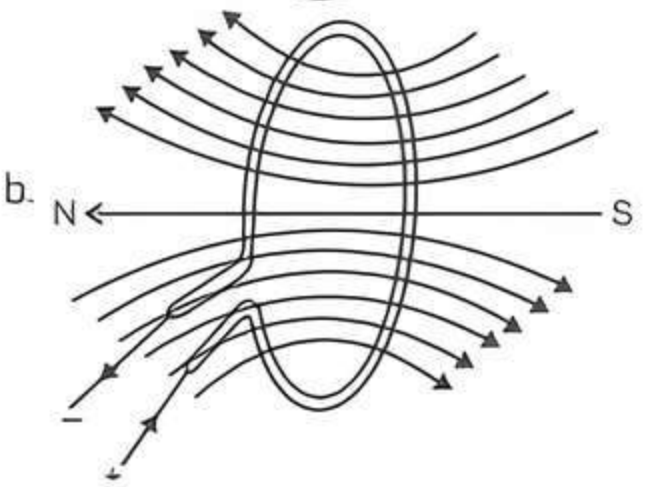
a. west b. north c. south d. east

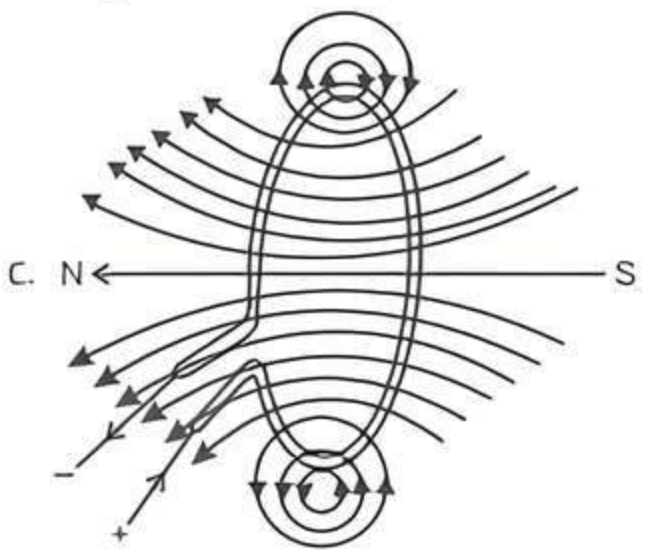
Q 8. Which of the following pattern correctly describes the magnetic field around a long straight current carrying wire? *(CBSE SQP 2022-23)*

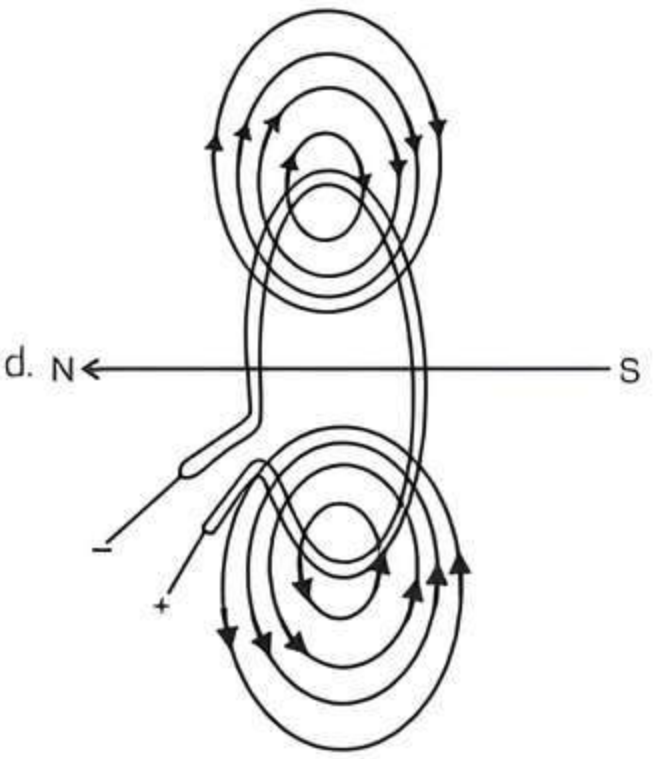
a. Straight lines perpendicular to the wire
b. Straight lines parallel to the wire
c. Radial lines originating from the wire
d. Concentric circles centred around the wire

Q 9. The correct pattern of magnetic field lines of the field produced by a current carrying circular loop is: *(CBSE 2023)*

a.


b.


c.


d.


Q 10. The factor/factors on which magnetic field strength produced by current carrying solenoid depends is/are:

a. magnitude of current
b. number of turns
c. nature of core material
d. All of the above

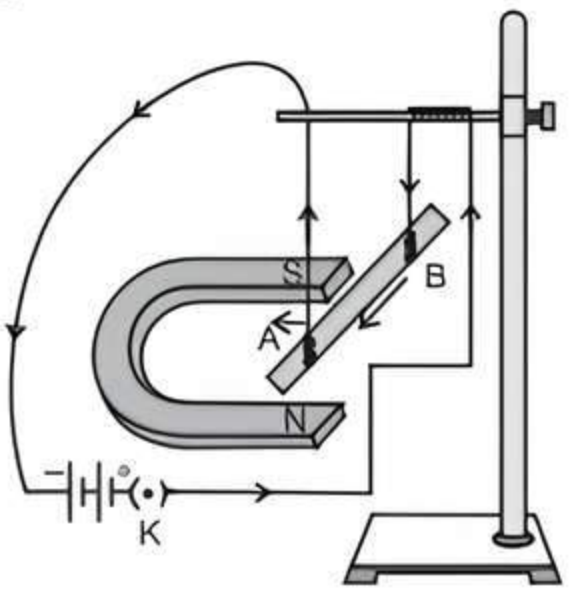
Q 11. The magnetic field of solenoid will not increase when:

a. the magnitude of current will increase
b. a soft iron core is inserted inside the solenoid
c. a soft aluminium core is inserted inside the solenoid
d. the conductor is kept closed

Q 12. The most suitable material for making the core of an electromagnet is:

a. steel b. iron
c. soft iron d. aluminium

Q 13. The displacement of the rod is larger when the angle between direction of current and magnetic field is:

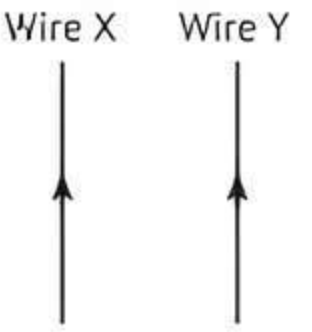


a. 30° b. 45° c. 90° d. 60°

Q 14. A magnetic field exerts no force on:

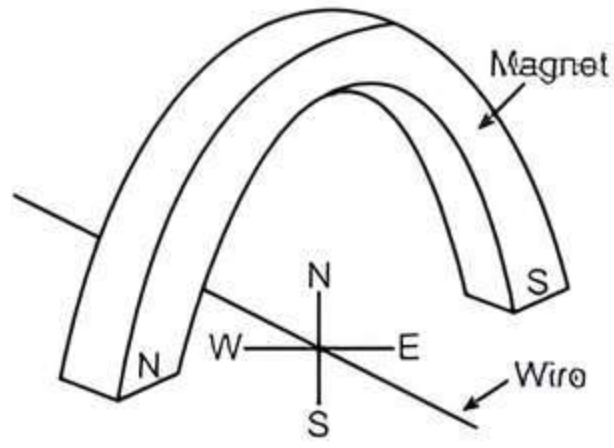
a. a stationary electric charge
b. a magnet
c. an electric charge moving perpendicular to its direction
d. an unmagnetised iron bar

Q 15. The long current-carrying wires are arranged in parallel as shown. What is the direction of the magnetic force on each wire?



	Wire X	Wire Y
a.	To the right	To the right
b.	To the left	To the left
c.	To the left	To the right
d.	To the right	To the left

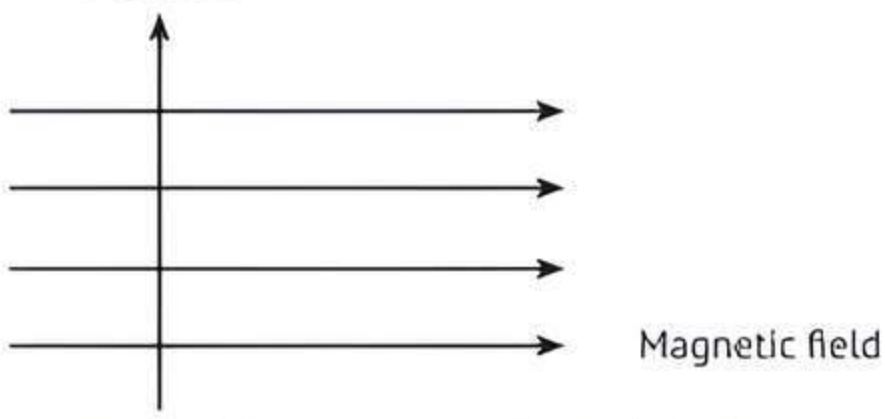
Q 16. A copper wire is held between the poles of a magnet.



The current in the wire can be reversed. The pole of the magnet can also be changed over. In how many of the four directions shown can the force act on the wire? *(CBSE SQP 2022-23)*

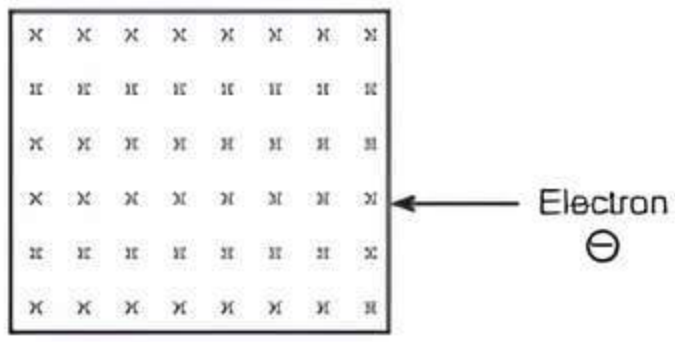
a. 1 b. 2 c. 3 d. 4

Q 17. A positron enters a uniform magnetic field at right angles to it as shown. The direction of force experienced by the positron will be: *(CBSE 2023)*



a. to the right b. to the left
c. into the page d. out of the page

Q 18. An electron is entering a region of magnetic field as shown. Given that the magnetic field direction is into the paper. In which direction will the deflection of the electron occur?



a. Into the paper
b. Out of the paper
c. Towards the bottom of the paper
d. Towards the top of the paper

Q 19. At the time of short circuit, the current in the circuit:

a. vary continuously b. reduces considerably
c. increases heavily d. does not change

Q 20. When a fuse is rated at 8 A, it means:

a. it will work only if current is 8 A
b. it will burn if current exceeds 8 A
c. it will not work if current is less than 8 A
d. it has a resistance of 8 Ω

Assertion & Reason Type Questions

Directions (Q. Nos. 21-27): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 21. Assertion (A): Magnetic field lines do not intersect each other.

Reason (R): Magnetic field lines are imaginary lines, the tangent to which at any point gives the direction of the field at that point. *(CBSE 2023)*

Q 22. Assertion (A): A compass needle is placed near a current carrying wire. The deflection of the compass needle decreases when the magnitude of the current in the wire is increases.

Reason (R): The strength of a magnetic field at a point near the conductor increases on increasing the current. *(CBSE SQP 2023-24)*

Q 23. Assertion (A): On freely suspending a current-carrying solenoid, it comes to rest in Geographical N-S direction.

Reason (R): One end of current-carrying straight solenoid behaves as a North pole and the other end as a South pole, just like a bar magnet. *(CBSE SQP 2022-23)*

Q 24. Assertion (A): A solenoid tends to expand, when a current passes through it.

Reason (R): Two straight parallel metallic wires carrying current in same direction repel each other.

Q 25. Assertion (A): A current carrying straight conductor experiences a force when placed perpendicular to the direction of magnetic field.

Reason (R): The net charge on a current carrying conductor is always zero. *(CBSE 2023)*

Q 26. Assertion (A): In Fleming's left-hand rule, the direction of magnetic field, force and current are mutually perpendicular.

Reason (R): Fleming's left-hand rule is applied to measure the induced current.

Q 27. Assertion (A): A fuse in a circuit prevents damage to the appliances and the circuit due to overloading.

Reason (R): Overloading occurs when the live wire and the neutral wire come into direct contact.

Answers

1. (d) Oersted

Knowledge BOOSTER

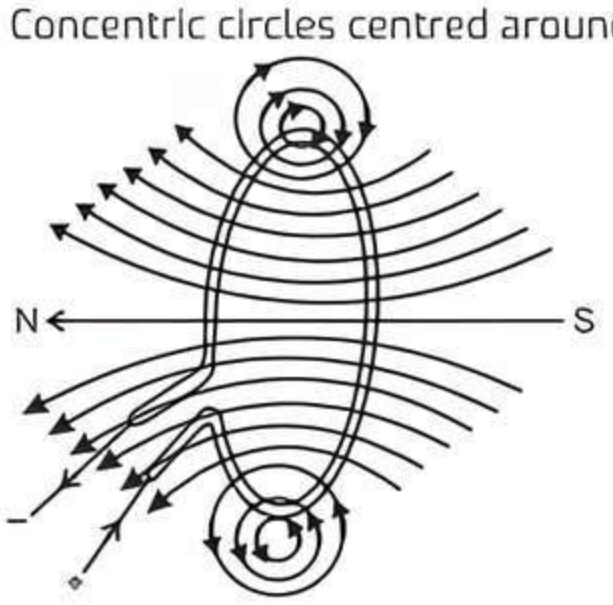
Hans Christian Oersted was the first who discovered that a compass needle got deflected when an electric current is passed through a metallic wire placed nearby.

2. (a) Magnetic needle
3. (c) If the key is taken out, then there will be no current in the circuit. *i.e.*, no magnetic field due to circuit. So, only earth magnetic field will be present and field due to it will be straight lines parallel to each other.

TiP

The needle of a compass is a magnet.

4. (c) If magnetic field lines are parallel and equidistant then, they represent zero field strength.
5. (b) never intersect each other
6. (c) *R*
7. (d) east
8. (d) Concentric circles centred around the wire
9. (c)



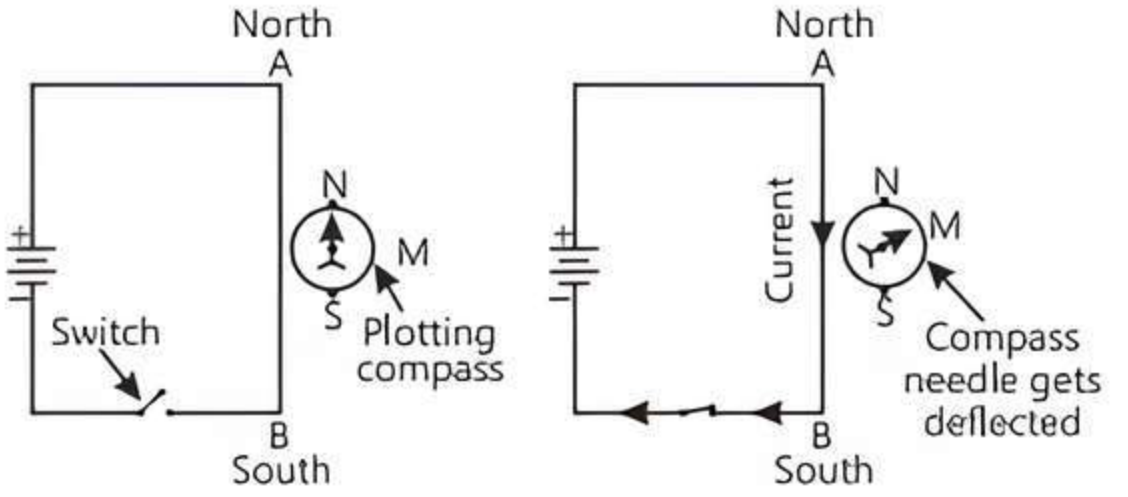
10. (d) All of the above
11. (b) a soft iron core is inserted inside the solenoid
12. (c) soft iron
13. (c) Maximum force is experienced when the current and magnetic fields are perpendicular to each other.
14. (a) a stationary electric charge
15. (d) **Wire *X*** — To the right. **Wire *Y*** — To the left
16. (b) 2 (Either north or south)
17. (c) into the page
18. (d) Towards the top of the paper.
19. (c) increases heavily
20. (b) it will burn if current exceeds 8 A
21. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
22. (d) Assertion (A) is false but Reason (R) is true.
23. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
24. (d) Solenoid tends to contract as the turns of the solenoid attract each other when current flows through them in the same direction.
25. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is snot the correct explanation of Assertion (A).
26. (c) Assertion (A) is true but Reason (R) is false.
27. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

Oersted, one of the leading scientists of the 19th century discovered that a compass needle got deflected when an electric current is passed through a metallic wire placed nearby.

The following experiment is shown by a teacher to describe Oersted's experiment to his students.



Read the above passage carefully and give the answer of the following questions:

Q 1. Oersted experiment explained ..... effect of current.

a. electric field
b. magnetic field
c. Both a. and b.
d. None of these

Q 2. In the earth's magnetic field alone, the compass needle rest along in which direction?

a. East-west
b. North-east
c. South-north
d. No fixed direction

Q 3. By which instrument the presence of magnetic field at a point can be detected?

a. A strong magnet
b. A solenoid
c. A compass needle
d. A current carrying line

Q 4. On reversing the direction of current in a wire, the magnetic field produced by it:

a. gets reversed in direction
b. increases in strength
c. decreases in strength
d. remains unchanged in strength and direction

Q 5. **How can you find the direction of magnetic field from a magnetic field line?**

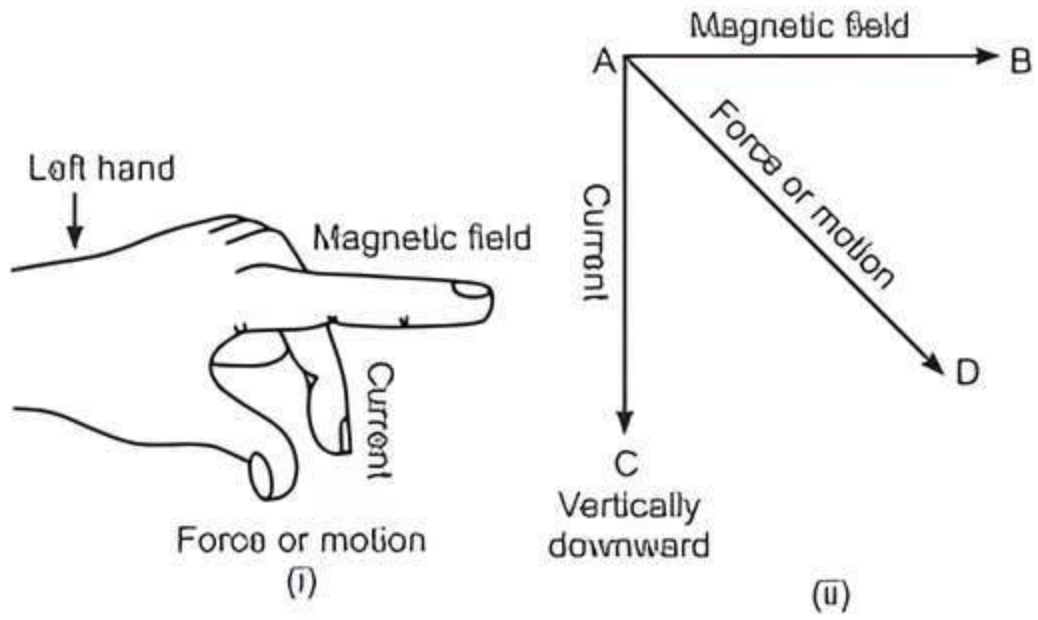
a. We can't say from magnetic field line
b. Along the perpendicular to the field line
c. Along the parallel to the field line
d. Along the tangent at any point of the field line

Answers

1. (b) magnetic field
2. (c) South-north
3. (c) A compass needle
4. (a) gets reversed in direction
5. (d) Along the tangent at any point of the field line

Case Study 2

Andre Marie Ampere suggested that a magnet must exert an equal and opposite force on a current carrying conductor, which was experimentally found to be true. But we know that current is due to charges in motion. Thus, it is clear that a charge moving in a magnetic field experience a force, except when it is moving in a direction parallel to it. If the direction of motion is perpendicular to the direction of magnetic field, the magnitude of force experienced depends on the charge, velocity (v), strength of magnetic field (B), and sine of the angle between v and B. Direction of magnetic force is given by Fleming's left-hand rule.



Read the above passage carefully and give the answer of the following questions:

Q 1. **If an electron is travelling horizontally towards east, a magnetic field in vertically downward direction exerts a force on the electron along:**

a. east b. west c. north d. south

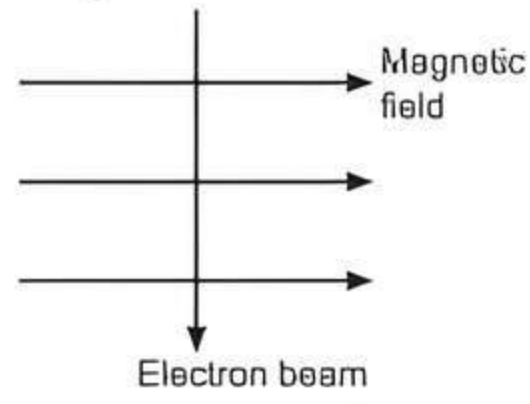
Q 2. **If a charged particle is moving along a magnetic field line, the magnetic force on the particle is:**

a. along its velocity
b. opposite to its velocity
c. perpendicular to its velocity
d. zero

Q 3. **A magnetic field exerts no force on:**

a. a stationary electric charge
b. a magnet
c. an electric charge moving perpendicular to its direction
d. an unmagnetised iron bar

Q 4. **An electron beam enters a magnetic field at right angle to it as shown in the figure. The direction of force acting on the electron beam will be:**



a. to the left b. to the right
c. to the page d. out of the page

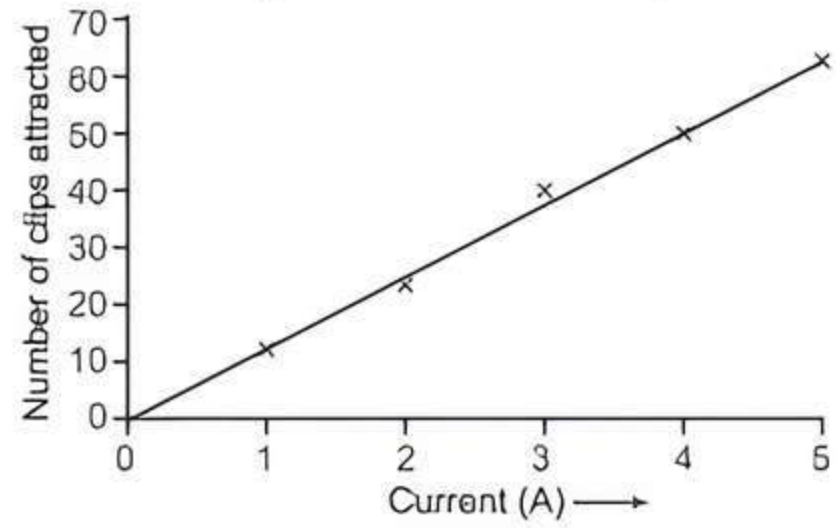
Answers

1. (d) Fleming's left-hand rule is used to determine the direction of force on electron *i.e.*, in south direction.
2. (d) The angle between velocity and magnetic field is zero. Therefore, magnetic force on the particle is zero.
3. (d) an unmagnetised iron bar
4. (c) to the page

Case Study 3

An electromagnet is a magnet consisting of a long coil of insulated copper wire wrapped around a soft iron core that is magnetised only when electric current is passed through the coil. Soft iron is used as core of an electromagnet because soft iron loses all of its magnetism when current in the coil is switched off. The strength of an electromagnet is depends on a few factors such as number of turns in the coil, current flowing in the coil, etc.

The following graph is obtained by a student while doing an experiment to see how current affects the strength of an electromagnet.



Read the above passage carefully and give the answer of the following questions.

Q 1. **Name two factors on which the strength of a magnetic field of an electromagnet depends.**

Q 2. **Which kind of energy change takes place in an electromagnet?**

Q 3. **Which material is used to make electromagnets and why?**

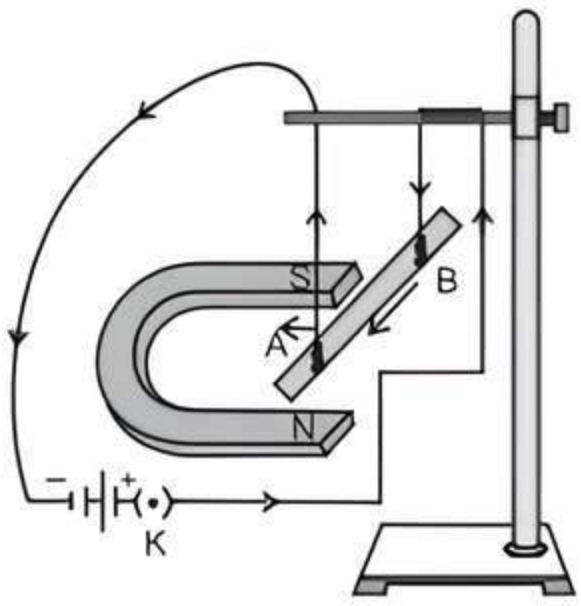
Q 4. **Why soft iron is used as a core of an electromagnet?**

Answers

1. The strength of an electromagnet depends on the number of turns in the coils and the strength of the current passing through the coil.
2. The energy change that takes place in an electromagnet is electrical energy to magnetic energy.
3. Soft iron is used to make electromagnets because soft iron loses all of its magnetism when current in the coil is switched off.
4. Because soft iron loses all of its magnetism when current in the coil is switched off.

Case Study 4

A student was asked to perform an experiment to study the force on a current carrying conductor in a magnetic field. He took a small aluminium rod *AB*, a strong horse-shoe magnet, some connecting wires, a battery and a switch and connected them as shown. He observed that on passing current, the rod gets displaced. On reversing the direction of current, the direction of displacement also gets reversed. On the basis of your understanding of this phenomenon, answer the following questions:



Read the above passage carefully and give the answer of the following questions:

Q 1. Why does the rod get displaced on passing current through it?

Q 2. State the rule that determines the direction of the force on the conductor AB.

Q 3. (i) If the U shaped magnet is held vertically and the aluminium rod is suspended horizontally with its end *B* towards due north, then on passing current through the rod from B to A as shown, in which direction will the rod be displaced?

(ii) Name any two devices that use current carrying conductors and magnetic field.

Or

Draw the pattern of magnetic field lines produced around a current carrying straight conductor held vertically on a horizontal cardboard. Indicate the direction of the field lines as well as the direction of current flowing through the conductor.

(CBSE 2022 Term-2)

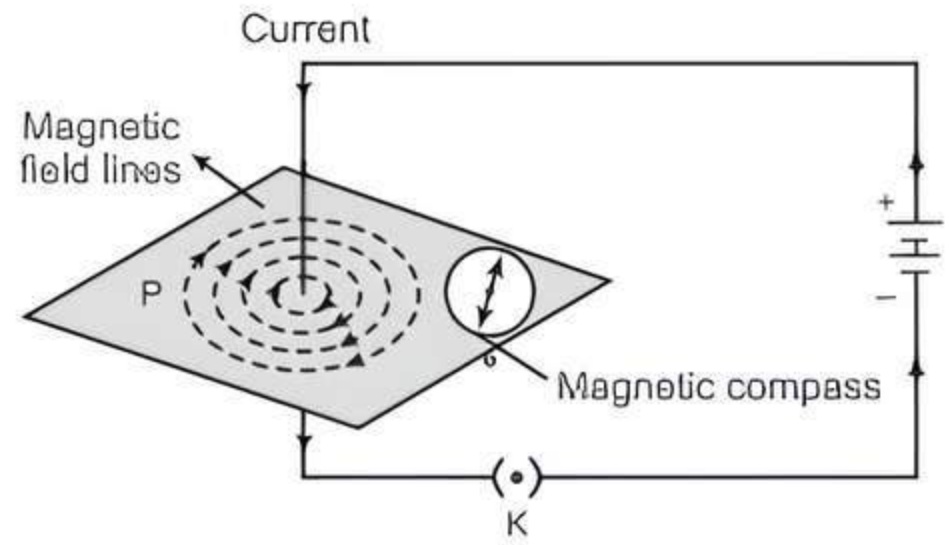
Answers

1. When a current-carrying conductor is placed in a magnetic field, a mechanical force is exerted on the conductor which makes rod displaced.
2. Fleming's left hand rule determines the direction of the force on the conductor AB.

   According to this rule, stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If the first finger point in the direction of magnetic field and the second finger in the direction of current then the thumb will point in the direction of motion or the force acting on the conductor.
3. (i) Towards the left.

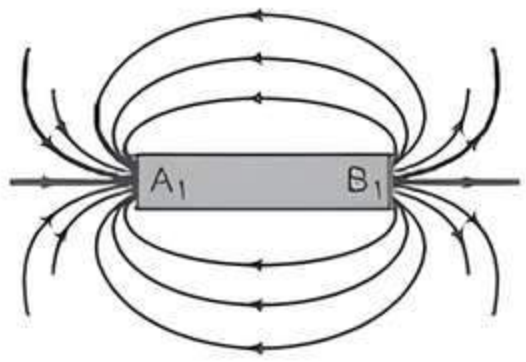
   (ii) Electric motor and electric generator.

Or



Very Short Answer Type Questions ↘

Q 1. Identify the poles of the magnet in the given figure:



Ans. B_1 is north pole and A_1 is south pole because the field lines emerge from north pole and merge at the south pole.

Q 2. State the direction of magnetic field inside a bar magnet.

Ans. Inside a bar magnet, the direction of magnetic field is from its south pole to its north pole.

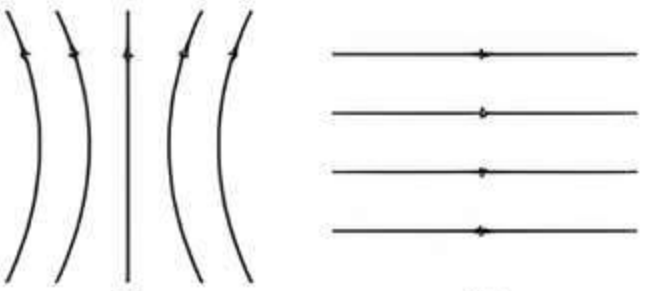
Q 3. A magnetic compass shows a deflection when placed near a current carrying wire. How will the deflection of the compass get affected if the current in the wire is increased? *(NCERT EXEMPLAR)*

Ans. The deflection increases because the strength of magnetic field is directly proportional to the magnitude of current passing through the straight conductor.

Q 4. What does the direction of thumb indicate in the right-hand thumb rule? *(NCERT EXEMPLAR)*

Ans. The thumb indicates the direction of current in the straight conductor held by curled fingers.

Q 5. Identify the type of magnetic field represented by the magnetic field lines given below and name the type of conductors which can produce them.

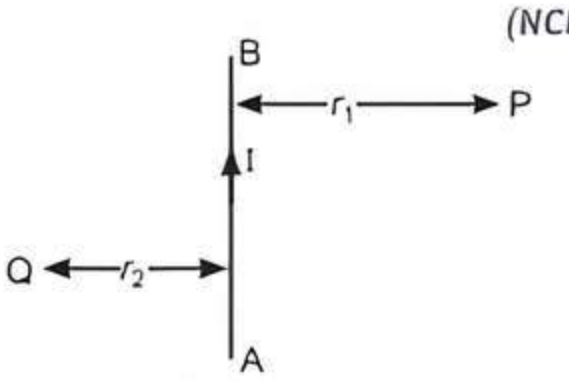


(i) (ii)

Ans. (I) Magnetic field lines of a current carrying circular loop.

(ii) Magnetic field lines in a solenoid.

Q 6. AB is a current carrying conductor in the plane of the paper as shown in figure. Given $r_1 > r_2$, where will the strength of the magnetic field be larger? *(NCERT EXEMPLAR)*



Ans. The strength of the magnetic field is larger at the point located closer *i.e.*, at *Q*.

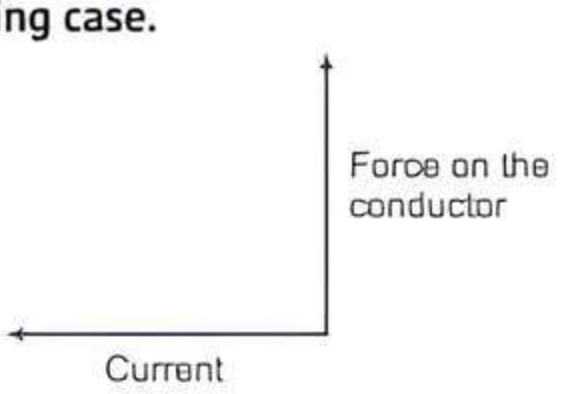
Q 7. What does the divergence of magnetic field lines near the ends of a current carrying straight solenoid indicate? *(NCERT EXEMPLAR)*

Ans. The divergence indicates the decrease in strength of magnetic field near and beyond the ends of the solenoid.

Q 8. When is the force experienced by a current carrying conductor placed in a magnetic field is maximum?

Ans. A current carrying conductor experience maximum force in a magnetic field when the direction of current is perpendicular to the magnetic field.

Q 9. State the direction of magnetic field in the following case.



Ans. The direction is perpendicular to the plane of paper in the outward direction by using Fleming's left-hand rule.

Short Answer Type-I Questions

Q 1. A compass needle is placed near a current carrying straight conductor. State your observation for the following cases and give reasons for the same in each case:

(i) Magnitude of electric current is increased.

(ii) The compass needle is displaced away from the conductor. *(CBSE 2019)*

Ans. (i) Magnetic field strength is directly proportional to the electric current, so the deflection of the needle increases.

(ii) Magnetic field strength is inversely proportional to the distance from the wire, so the deflection of the needle decreases.

Q 2. It is established that an electric current through a conductor produces a magnetic field around it. Is there a similar magnetic field produced around a thin beam on moving (I) α- particles, (II) neutrons? Justify your answer in each case. *(CBSE 2019)*

Ans. (I) α- particles, being positively charged, constitutes a current in the direction of motion. So, a magnetic field is produced.

(ii) The neutrons, being electrically neutral, constitute no current. So, no magnetic field is produced.

Q 3. List four properties of magnetic field lines. *(CBSE 2019)*

Ans. Four properties of magnetic field lines are as follows:

(i) The field lines emerge from north pole and merge at south pole.

(ii) The magnetic field lines are stronger at poles.

(iii) The magnetic field lines do not cross /intersect each other.

(iv) The magnetic field lines are closed curves.

COMMON ERROR

Students often repeat the same properties in different words.

Q 4. When is the force experienced by a current carrying straight conductor placed in a uniform magnetic field:

(i) maximum

(ii) minimum? *(CBSE 2022 Term-2)*

Ans. **(i) Maximum:** When the current carrying conductor is placed perpendicular to magnetic field.

(ii) Minimum: When the current carrying conductor is placed parallel to the magnetic field.

Q 5. (I) Name the poles P, Q, R and S of the magnets in the following figures 'a' and 'b'

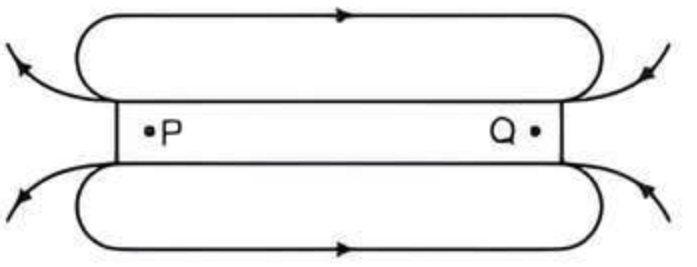


Figure 'a'

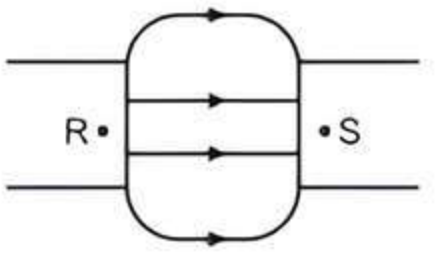


Figure 'b'

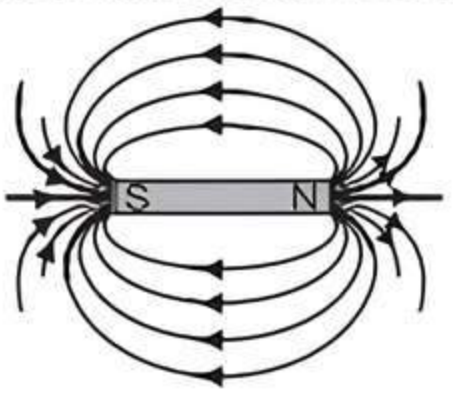
(ii) State the inference drawn about the direction of the magnetic field lines on the basis of these diagrams. *(CBSE 2022 Term-2)*

Ans. (i) P → North pole
Q → South pole
R → North pole
S → South pole

(ii) The magnetic field lines emerge from north pole and merge at the south pole.

Q 6. Draw magnetic field lines around a bar magnet. *(CBSE 2019)*

Ans. Magnetic field lines around a bar magnet:

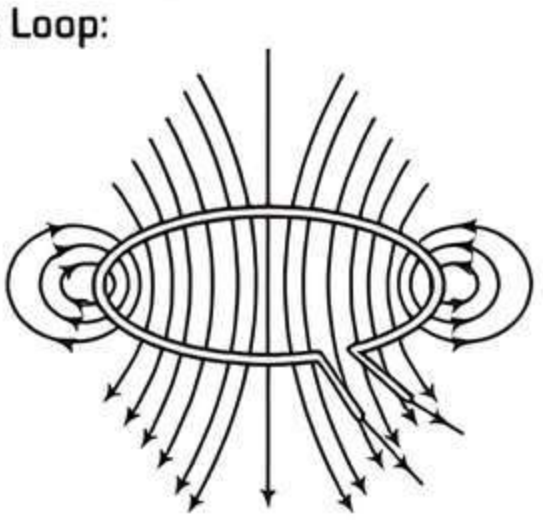


COMMON ERROR

Many students fail to show the correct direction of magnetic field.

Q 7. Consider a circular loop of thick copper wire lying horizontally on a table. Let the current pass through the loop anticlockwise. Draw the magnetic field lines to show the direction and the pattern of the magnetic field inside and outside the loop. *(CBSE 2023)*

Ans. Magnetic Field Lines Due to a Current Carrying Circular Loop:



Q 8. Meena draws magnetic field lines of field close to the axis of a current carrying circular loop. As she moves away from the centre of the circular loop, she observes that the lines keep on diverging. How will you explain her observation? *(NCERT EXEMPLAR)*

Ans. Strength of the magnetic field decreases as distance increases. This is indicated by the decrease in degree of closeness of the field lines.

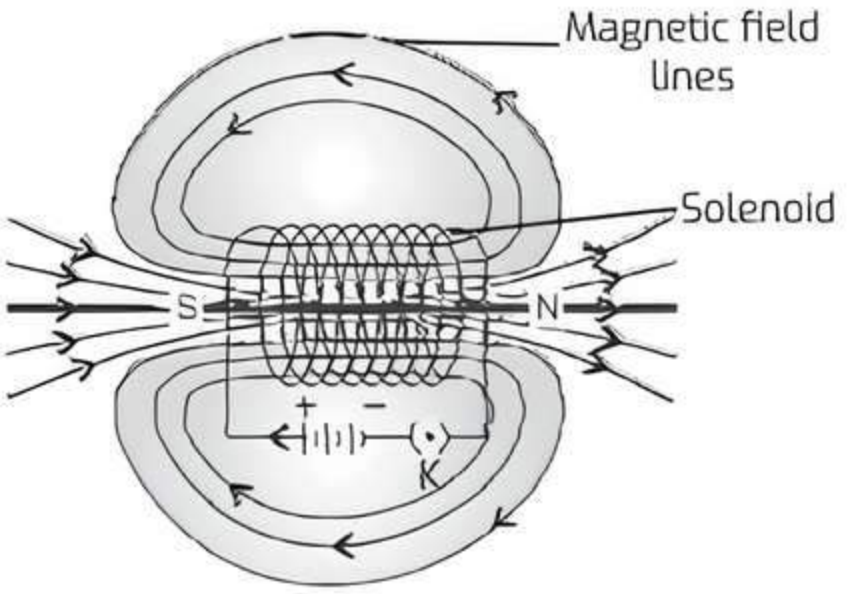
Q 9. Draw magnetic field lines in and around a current carrying straight solenoid. *(CBSE 2019)*

Ans.

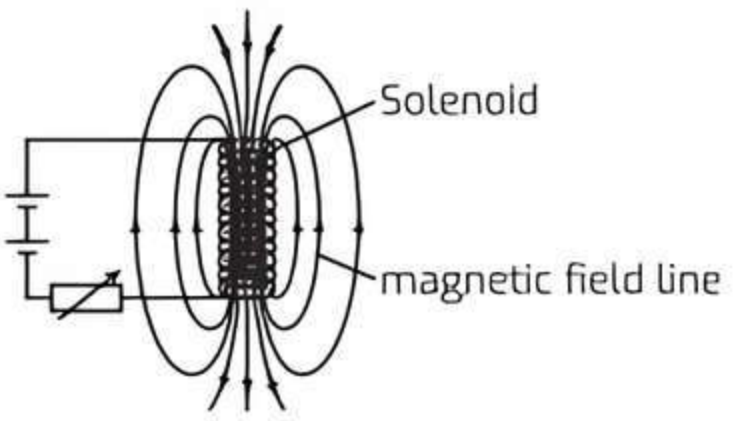
TiP

Students should draw neat diagrams along with the arrows indicating the direction of magnetic field.

Magnetic field lines in and around a current carrying straight solenoid:



Q 10. A circuit contains a battery, a variable resistor and a solenoid. The figure below show the magnetic field pattern produced by the current in the solenoid.



(i) State how the magnetic field pattern indicates regions where the magnetic field is stronger?

(ii) What happens to the magnetic field when the current in the circuit is reversed?

(CBSE SQP 2023-24)

Ans. (i) Relative closeness of field lines indicates the strength of magnetic field. Since field lines are crowded around the ends of the solenoid, hence these are the regions of strongest magnetism.

(ii) The direction of the field will also be reversed.

Q 11. Under what conditions permanent electromagnet is obtained if a current carrying solenoid is used? *(NCERT EXEMPLAR)*

Ans. The conditions to obtain permanent electromagnet if a current carrying solenoid is used are:

(i) The current through the solenoid should be direct current.

(ii) The rod inside is made of a magnetic material such as steel.

Q 12. What is the role of fuse, used in series with any electrical appliance? Why should a fuse with defined rating not be replaced by one with a larger rating? *(NCERT EXEMPLAR)*

Ans. Fuse is used for protecting appliances from short-circuiting or overloading.

When a fuse with defined rating for a particular appliance is replaced by one with larger rating, it does not blow off and the appliance is damaged due to larger current passing through it.

Q 13. Differentiate between overloading and short-circuiting.

Ans. Difference between overloading and short-circuiting:

S.No.	Basis of Difference	Overloading	Short-circuiting
1.	Cause	It occurs when too many appliances are connected to a single socket.	It occurs when live wire comes in contact with the neutral wire.
2.	Amount of current	Low amount of current flows through the circuit as compared to short-circuit.	High amount of current flows through the circuit.

TiP

Always learn the differences in tabular form for easy remembrance than in paragraph form.

Short Answer Type-II Questions

Q 1. A student fixes a white sheet of paper on a drawing board. He places a bar magnet in the centre and sprinkles some iron fillings uniformly around the bar magnet. Then he taps gently and observes that iron filings arrange themselves in a certain pattern.

(i) Why do iron filings arrange themselves in a particular pattern?

(ii) Which physical quantity is indicated by the pattern of field lines around the bar magnet?

(iii) State any two properties of magnetic field lines. *(CBSE SQP 2022-23)*

Ans. (i) When iron filings are placed in a magnetic field around a bar magnet, they behave like tiny magnets. The magnetic force experienced by these tiny magnets make them rotate and align themselves along the direction of field lines.

(ii) The physical property indicated by this arrangement is the magnetic field produced by the bar magnet.

(iii) Two properties of magnetic field lines are as follows:

(a) Magnetic field lines never intersect.

(b) Magnetic field lines are closed curves.

Q 2. What are magnetic field lines? Justify the following statements:

(i) Two magnetic field lines never intersect each other.

(ii) Magnetic field lines are closed curves. *(CBSE 2015)*

Ans. Magnetic field lines are imaginary lines along which the north magnetic pole tends to move in a magnetic field.

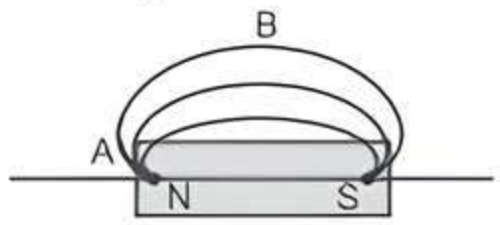
(I) The magnetic lines of force never intersect (or cross) each other. If they do so, then at the point of intersection, there will be two different directions of the same magnetic field, which is not possible.

(II) Magnetic field lines are closed continuous curves. These lines emerge out from the north pole of a bar magnet and merge into its south pole. Inside the magnet, they move from south pole to north pole.

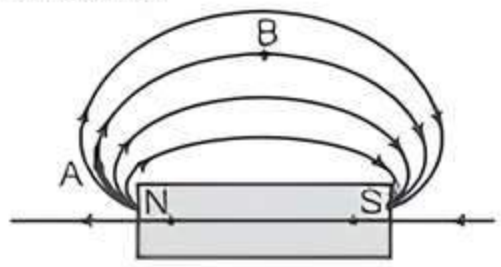
TiP

Definitions and explanations of technical terms must be precise and complete.

Q 3. Magnetic field lines are shown in the given diagram. A student makes a statement that the magnetic field at 'A' is stronger than at 'B'. Justify this statement. Also redraw the diagram and mark the direction of magnetic field lines. *(CBSE 2019)*



Ans. The relative strength of the magnetic field is shown by the degree of closeness of the field lines. The degree of closeness is more at A than at B. Therefore, the magnetic field is stronger at A where the field lines are crowded.



Q 4. A compass needle is placed near a current carrying wire. State your observations for the following cases and give reasons for the same in each case:

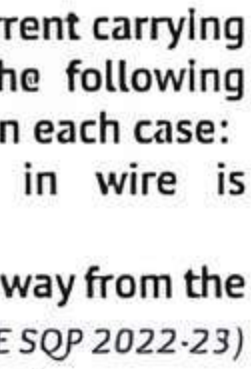
(i) Magnitude of electric current in wire is increased.

(ii) The compass needle is displaced away from the wire. *(CBSE SQP 2022-23)*

Ans. (i) The deflection in the compass needle increases as magnetic field of the current carrying conductor is directly proportional to current flowing through it.

(ii) The deflection in the needle decreases as the magnetic field is inversely proportional to the perpendicular distance from the wire.

Q 5. The following diagram shows two parallel straight conductors carrying same current. Copy the diagram and draw the pattern of the magnetic field lines around them showing their directions. What is the magnitude of magnetic field at a point 'X' which is equidistant from the conductors? Give justification for your answer. *(CBSE 2019)*

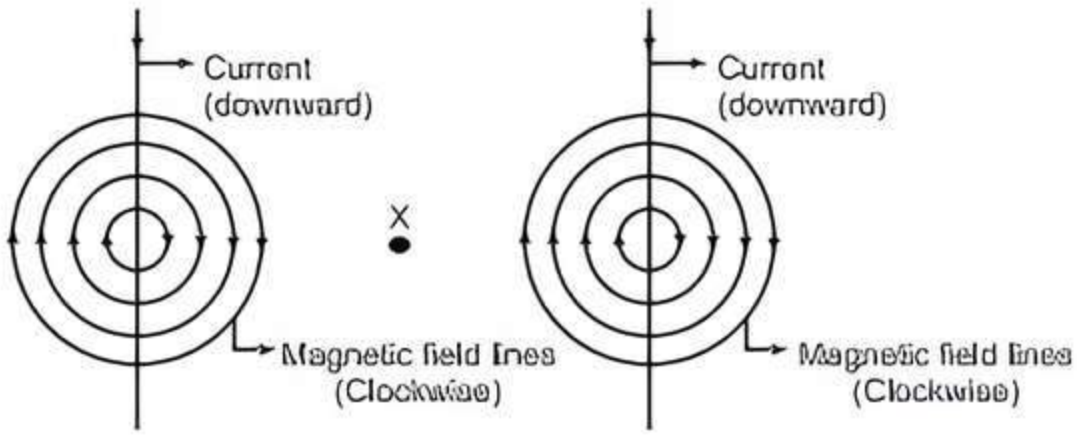


Ans.

TiP

Clear your knowledge on this concept and practice drawing the correct pattern of magnetic field along with the arrows indicating the direction of magnetic field.

Applying right-hand thumb rule, as both the wires have current flowing in downward direction, hence the magnetic field will be clockwise for both of them as shown in the figures.



At point X, the magnetic field due to both conductors has opposite directions and as the point is equidistant from the conductors so the net magnitude of the magnetic field at point X will be zero.

Q 6. State right-hand thumb rule to determine the direction of magnetic field around a current carrying conductor. Apply this rule to find the direction of magnetic field inside and outside a circular loop of wire lying in the plane of a table and current is flowing through it clockwise.

(CBSE 2019)

Ans. Right-hand thumb rule states that if a current carrying conductor is held in the right-hand in such a way that thumb indicates the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor.

The magnetic field will be directed perpendicular into the plane of table inside the circular loop.

The magnetic field will be directed perpendicular outside the plane of table for a point outside the circular loop.

Hence, the direction of magnetic field lines inside the loop will be entering into the table while outside the loop, they will be emerging from the table.

COMMON ERROR

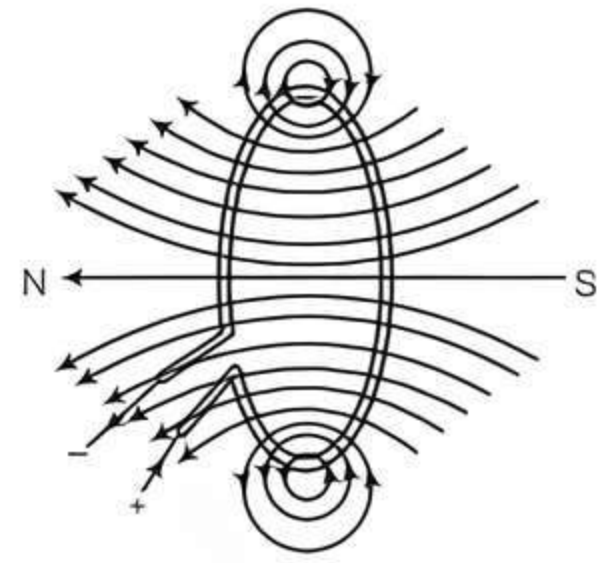
Students do not learn the statement of rule properly or identify incorrect rules.

Q 7. (i) Draw the pattern of magnetic field lines due to a magnetic field through and around a current carrying circular loop.

(ii) Name and state the rule to find out the direction of magnetic field inside and around the loop.

(CBSE 2020, 22 Term-2)

Ans. (i) Magnetic field lines through and around a current carrying circular loop:



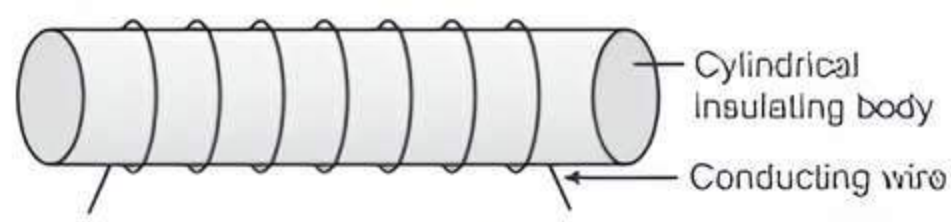
(ii) Right-hand thumb rule is used to find the direction of magnetic field inside and around a current carrying circular loop.

It states that if a current carrying conductor is held in the right-hand in such a way that thumb indicates the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor.

Q 8. What is meant by solenoid? How does a current carrying solenoid behave? Give its main use.

(CBSE 2015, 16)

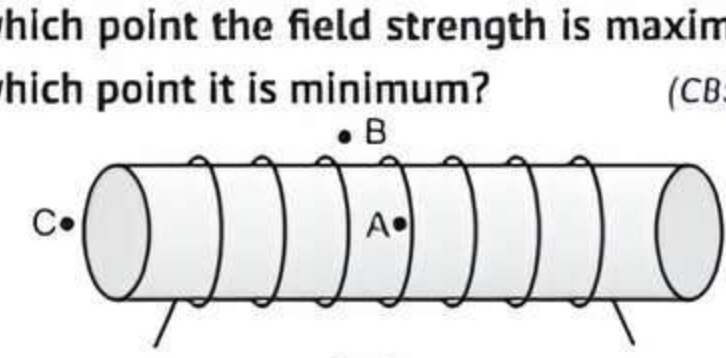
Ans. Solenoid is a coil of many circular turns of insulated copper wire wound on a cylindrical insulating body (*i.e.*, cardboard, etc.) such that its length is greater than its diameter.



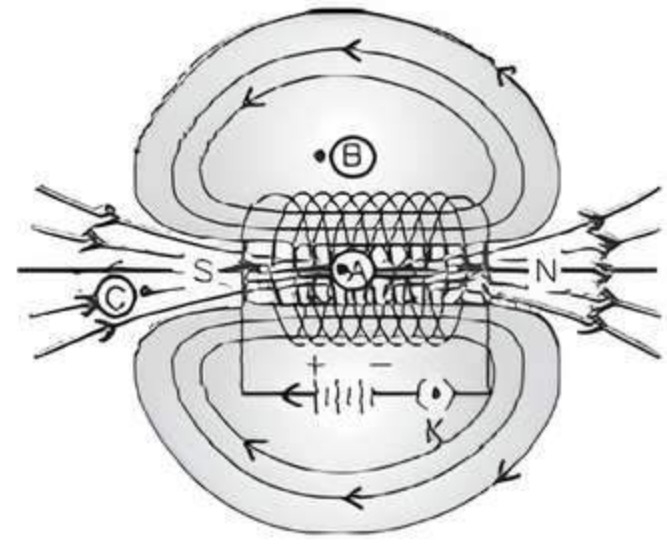
When current is passed through the solenoid, the magnetic field line pattern resembles exactly with a bar magnet with the fixed polarity, *i.e.*, north and south pole at its end. Hence, the current carrying solenoid behaves like a bar magnet.

Use of a Current Carrying Solenoid: A temporary magnet (electromagnet) can be formed by the use of a solenoid.

Q 9. For the current carrying solenoid as shown below, draw magnetic field lines and giving reason, explain that out of the three points A, B and C at which point the field strength is maximum and at which point it is minimum? *(CBSE 2023, 15)*



Ans.



Outside the solenoid, the magnetic field is minimum. At the end point C of the solenoid, the magnetic field strength is half of that inside it. So, it will be minimum at point B and maximum at point A.

Q 10. Give reasons for the following:

(i) There is either a convergence or a divergence of magnetic field lines near the ends of a current carrying straight solenoid.

(ii) The current carrying solenoid when suspended freely rests along a particular direction.

(iii) The burnt out fuse should be replaced by another fuse of identical rating. *(CBSE 2020)*

Ans. (i) Magnetic field lines diverge from N-pole and converge at S-pole because strength of magnetic field is higher near the poles.

(ii) Current carrying solenoid acts as a bar magnet which rests in North-south direction when suspended freely.

(iii) The burnt out fuse cannot be reused. Also, if a fuse with larger rating is used, the fuse wire will melt and hence would fail to serve the required purpose. So, new fuse of same rating should be used for electrical safety.

Q 11. (i) What is the function of earth wire in electrical instruments?

(ii) Explain what is short circuiting of an electric supply?

(iii) What is the usual current rating of the fuse wire in the line to feed:

(a) lights and fans?

(b) appliances of 2 kW or more power?

Ans. (i) Earth wire is used for safety measure to ensure that any leakage of current in a metallic body does not give any serious shock to a user.

(ii) Short circuiting occurs when live and neutral wires of an electric circuit come into direct contact.

(iii) The usual current rating of the fuse wire is:

(a) 5 A for light and fans

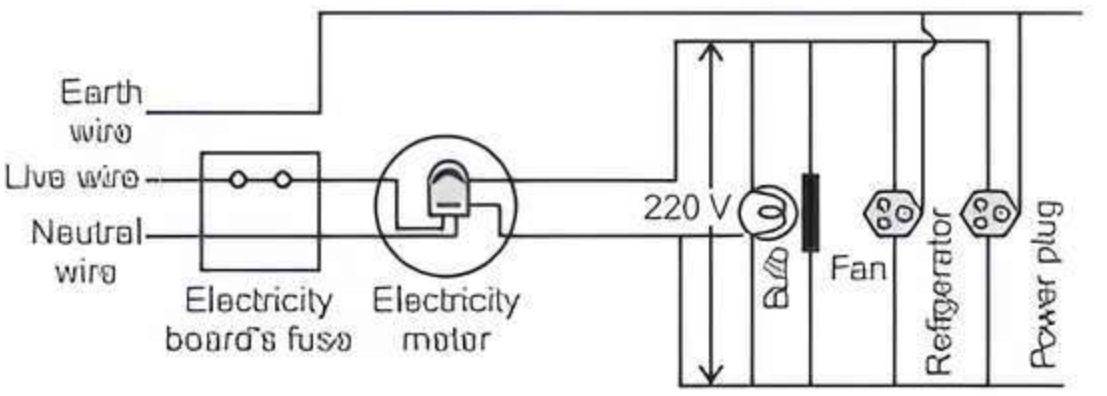
(b) 15 A for appliances of 2 kW or more power.

Q 12. Suppose your parents have constructed a two room house and you want that in the living room there should be a provision of one electric bulb, one electric fan, a refrigerator and a plug point for appliances of power up to 2 kW. Draw a circuit diagram showing electric fuse and earthing as safety devices.

Ans.

TiP

Draw correct and labelled circuit diagram. Marks will be deducted if all the parts of the circuit diagram are not correctly labelled.



Q 13. Anannya responded to the question: Why do electrical appliances with metallic bodies are connected to the mains through a three pin plug, whereas an electric bulb can be connected with a two pin plug?

She wrote: Three pin connections reduce heating of connecting wires.

(i) Is her answer correct or incorrect? Justify.

(ii) What is the function of a fuse in a domestic circuit? *(CBSE SQP 2023-24)*

Ans. (i) Anannya's answer is wrong. Electrical appliances with metallic bodies need an earth wire which provides a low resistance conducting path to the flow of current in case there is an accidental leakage of current through the conducting body of the appliances.

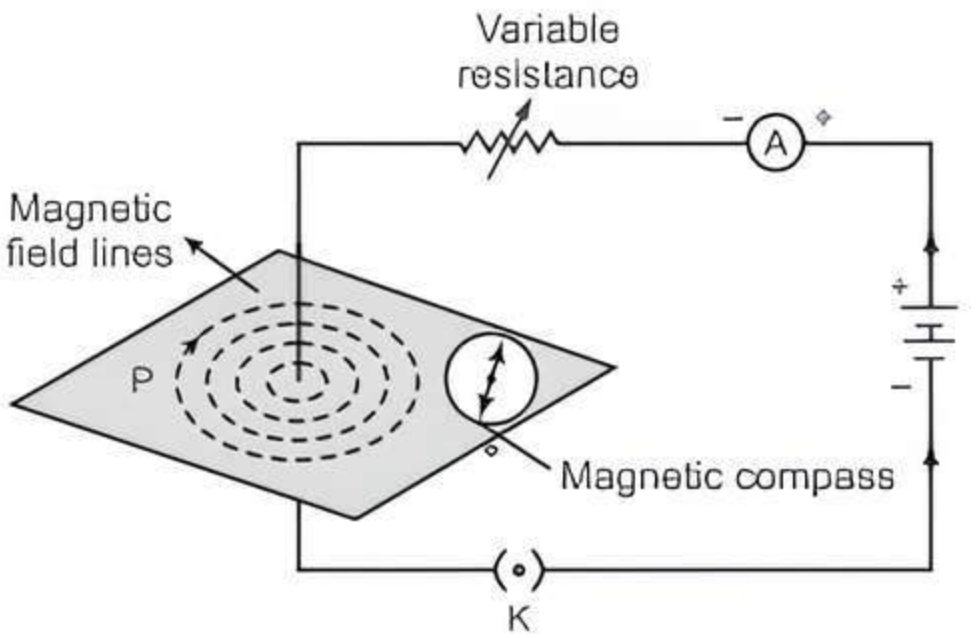
(ii) An electrical fuse is a safety device that operates to provide protection against the overflow of current in an electrical circuit. An important component of an electrical fuse is a metal wire or strip that melts when excess current flows through it.

Long Answer Type Questions

Q 1. (i) Draw magnetic field lines produced around a current carrying straight conductor passing through a cardboard. Name, state and apply the rule to mark the direction of these field lines.

(ii) How will the strength of the magnetic field change when the point where magnetic field is to be determined is moved away from the straight wire carrying constant current? Justify your answer. *(CBSE 2019)*

Ans. (i) To mark the direction of magnetic field lines, we use the right-hand thumb rule. According to this rule, if we hold a current carrying conductor in our right-hand such that thumb points towards the direction of current, the direction in which the fingers wrap the wire represent the direction of the magnetic field. As we can see in the figure that the current is going downwards, so the direction of magnetic field lines is clockwise

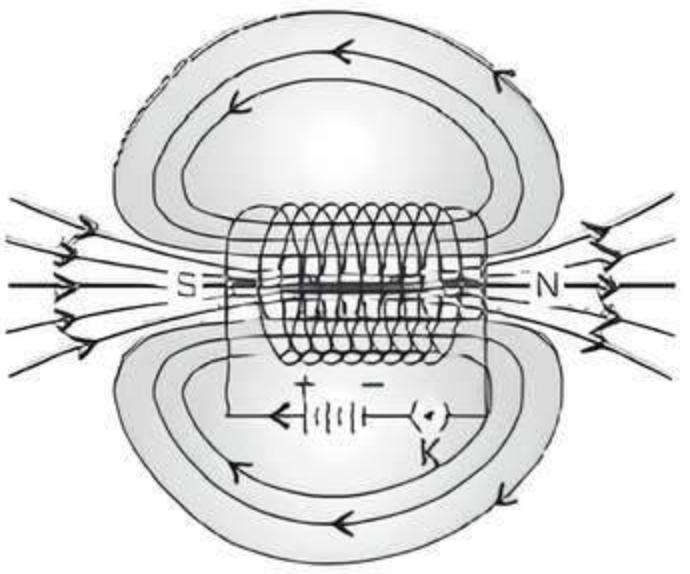


(ii) The strength of the magnetic field decreases when the point where magnetic field is to be determined is moved away from the straight wire carrying current because strength of the magnetic field is inversely proportional to the distance from the origin.

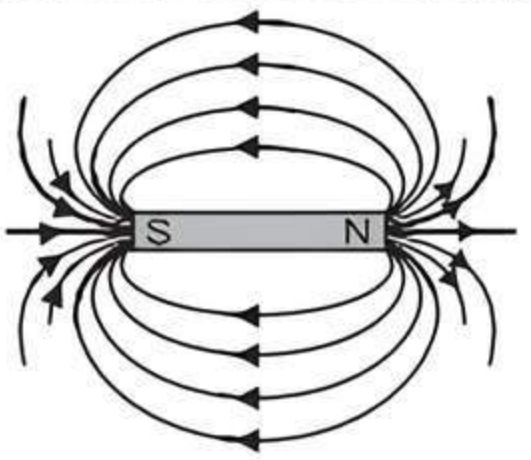
Q 2. What is a solenoid? Draw the pattern of magnetic field lines of (i) a current carrying solenoid and (ii) a bar magnet. List two distinguishing features between the two fields. *(CBSE 2019)*

Ans. A solenoid is a coil with many circular turns of insulated copper wire wrapped closely in the shape of a cylinder.

(I) Magnetic field lines of current carrying solenoid:



(ii) Magnetic field lines of a bar magnet:



COMMON ERROR

Students commit error in showing correct direction of magnetic field lines.

Distinguishing features between the two fields:

(i) The strength of magnetic field of the solenoid can be changed by changing current while the magnetic field strength due to bar magnet is constant.

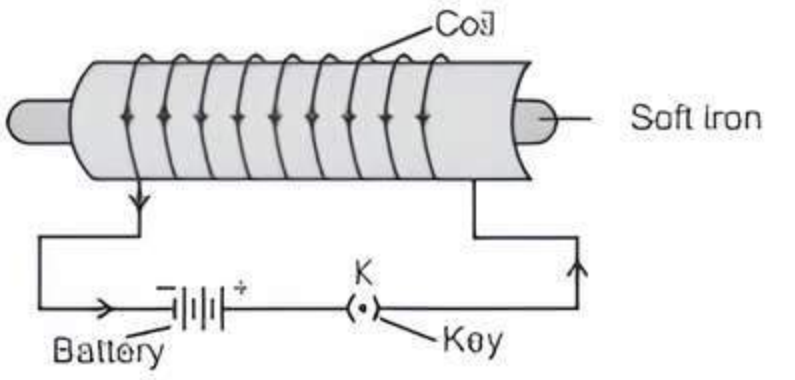
(ii) Solenoid produces magnetic field as long as current flows in its coils while bar magnet produces a permanent magnetic field.

Q 3. (i) What is an electromagnet? List any two uses.
(ii) Draw a labelled diagram to show how an electromagnet is made.
(iii) State the purpose of soft iron core used in making an electromagnet.
(iv) List two ways of increasing the strength of an electromagnet, if the material of the electromagnet is fixed. *(CBSE 2020)*

Ans. (I) An electromagnet refers to a magnetised solenoid which behaves like a magnet as long as electric current passes through it. An electromagnet consists of a long insulated copper wire wound around a soft iron core.

The electromagnets are used in electric motors, electric bells, loudspeakers, etc.

(ii) **Electromagnet diagram:**



(iii) Soft iron core is used to make electromagnets as it gains and looses magnetism quickly.

(iv) The strength of an electromagnet can be increased by:
(a) increasing the current.
(b) increasing the number of turns in the coil.

TiP

Learn and understand the concepts of both bar magnet and solenoid and make a list of how each one differs from the other one.

Q 4. With the help of a diagram of experimental set-up, describe an activity to show that the force acting on a current carrying conductor placed in a magnetic field increases with increase in field strength. *(CBSE 2015, 20)*

Ans. Objective: To show through an activity that force acting on a current carrying conductor placed in a magnetic field increases with increase in the field strength.

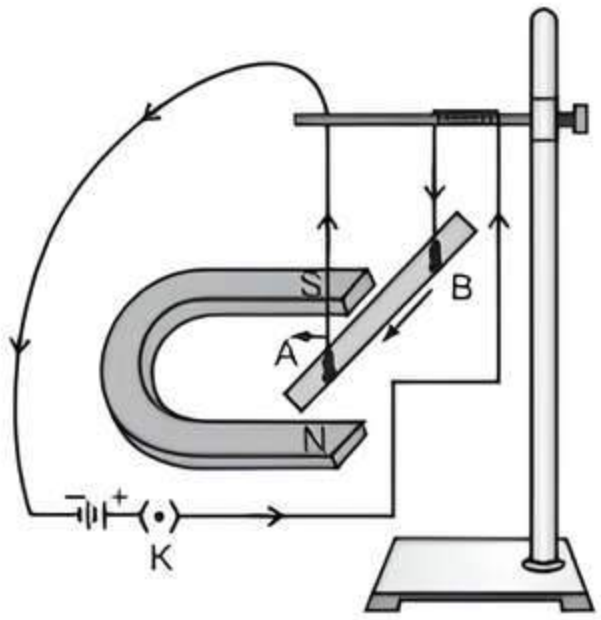
Apparatus Required: Aluminium rod, two horseshoe magnets of different intensities, a clamp stand, a cell, a key, a rod and connecting wires, etc.

Procedure:

(I) Firstly, the experimental set-up is arranged as shown in figure.

(ii) Plug the key for the given set-up. The current will flow through the rod from A and B and note the displacement of rod.

(iii) In this step, the key is unplugged and the first horseshoe magnet is removed. Now, place the second horseshoe magnet of a higher magnetic field strength in a similar manner as the first one.



(iv) Now, plug the key. The current again flows through the rod from A to B. Again observe the deflection of the rod.

(v) Now, bring both the magnets closer (to ensure greater magnetic field than that of previous case). Again observe the deflection of the rod.

Observation: Every time, the conductor deflects faster than that of previous one. It is possible only when the conductor gets more accelerated every time which requires more applied force. Thus, if the magnetic field strength is increased, the rod will exert a greater force and deflects even faster.

Conclusion: The force working on a current carrying conductor kept in a magnetic field increases with increase in the strength of field.

TiP

Students should write activity with the observation and proper labelled diagram.

Q 5. (i) Explain why there are two separate circuits one for high power rating appliances and other for low power rating appliances.

(ii) A domestic circuit has 5 A fuse. How many bulbs of rating 100 W, 220 V can be safely used in this circuit? Justify your answer.

Ans. (i) In the domestic wiring, two separate circuits are set—one for high power rating appliances namely power circuit and other for low power rating appliances called lightning circuit.

Power Circuit: The circuit drawing heavy current (15 A) from mains and used for high power rating devices such as geysers, washing machine, etc., is called power circuit.

Lightning Circuit: The circuit which draws small amount of current from the mains and is used for low power rating devices such as bulb, tubelight, fans, etc., having a current rating of 5 A, is called lightning circuit.

(ii) Given, power rating of bulb = 100 W, 220 V, $I = 5$ A, $V = 220$ V and $P = n \times 100$ W where n = Number of bulbs

Electric current flowing in the circuit

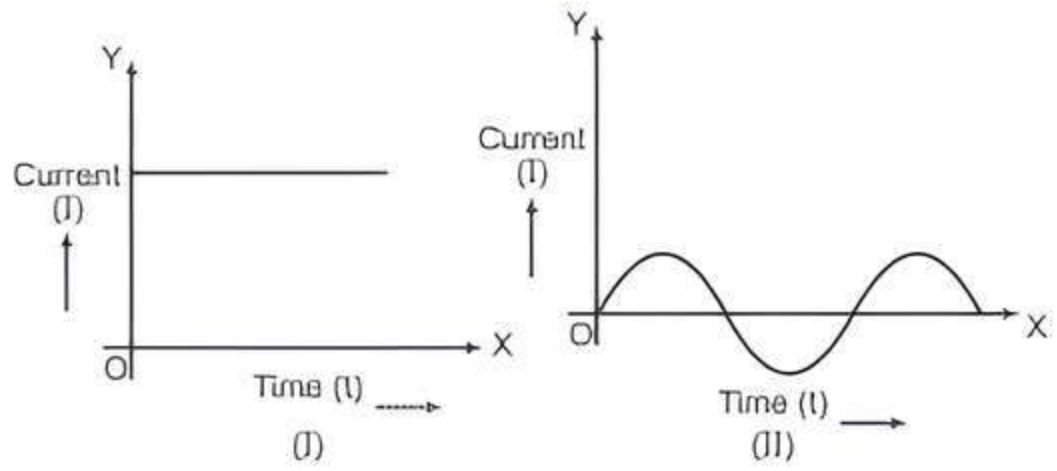
$$I = \frac{P}{V}$$

$$\Rightarrow \quad 5 = n \times \frac{100}{220}$$

$$\Rightarrow \quad n = 5 \times \frac{220}{100} = \frac{1100}{100} = 11$$

Hence, in the domestic circuit ,11 bulbs of 100 W can be used having potential difference of 220 V.

Q 6. In our daily life, we use two types of electric current whose current-time graphs are given below:



(i) Identify the types of current in each case.

(ii) Identify any one source of each type of current.

(iii) What is frequency of current used in domestic supply in India?

(iv) On the basis of graphs, write difference between the two currents.

(v) Out of two, which one is used in transmitting electric power over long distance and why?

(CBSE 2016)

Ans. (i) The types of current are: DC in case-I and AC in the case-II.

(ii) Source of DC – Cell or a battery.
Source of AC – Generator.

(iii) Frequency of AC used in domestic supply in India is 50 Hz whereas DC has zero frequency.

(iv) In case-I, current remains constant and the frequency is zero. But in case-II, current varies periodically with a frequency of 50 Hz in India.

(v) AC is used to transmit electric power over long distances without much loss of energy as compared to a DC transmission.

Chapter Test

Multiple Choice Questions

Q 1. The strength of magnetic field inside a long current carrying straight solenoid is:

a. more at the ends than at the centre

b. minimum in the middle

c. same at all points

d. found to increase from one end to the other

Q 2. Which of the following correctly describes the magnetic field near a long straight wire?

a. The field consists of straight lines perpendicular to the wire

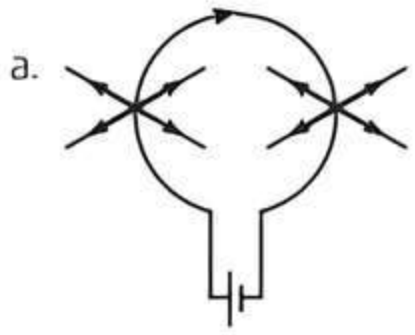
b. The field consists of straight lines parallel to the wire

c. The field consists of radial lines originating from the wire

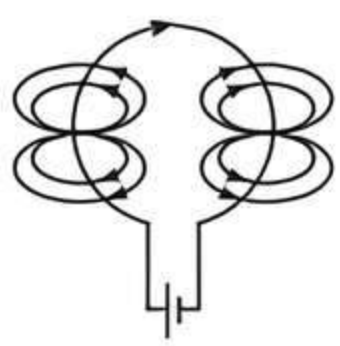
d. The field consists of concentric circles centred on the wire

Q 3. Which diagram shows the magnetic field lines around a current carrying circular loop?

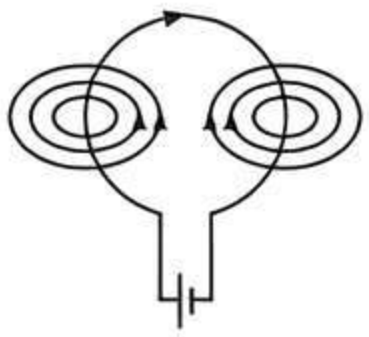
a.



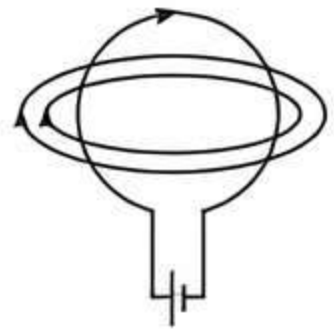
b.



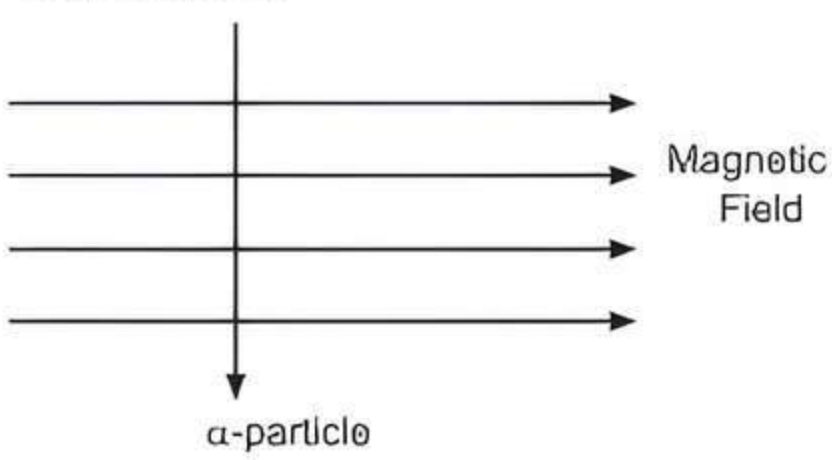
c.



d.



Q 4. An α-particle enters in a uniform magnetic field as shown. The direction of force experienced by the α-particle is:



a. towards right

b. towards left

c. into the page

d. out of the page

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.

d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): The strength of the magnetic field produced at the centre of a current carrying circular coil increases on increasing the radius of the circular coil.

Reason (R): Magnetic field strength is inversely proportional to the radius of the circular coil.

Q 6. Assertion (A): In Fleming's left-hand rule, the direction of magnetic field, force and current are mutually perpendicular.

Reason (R): Fleming's left-hand rule is applied to measure the induced current.

Case Study Based Question

Q 7. Different magnetic field patterns are produced by current carrying conductors having different shapes.

The magnetic field lines around a straight conductor (straight wire) carrying current are concentric circles whose centres lie on the wire. It has been shown by experiments that the magnitude of magnetic field produced by a straight current carrying wire at a given point is: (i) directly proportional to the current passing in the wire, and (ii) inversely proportional to the distance of that point from the wire.

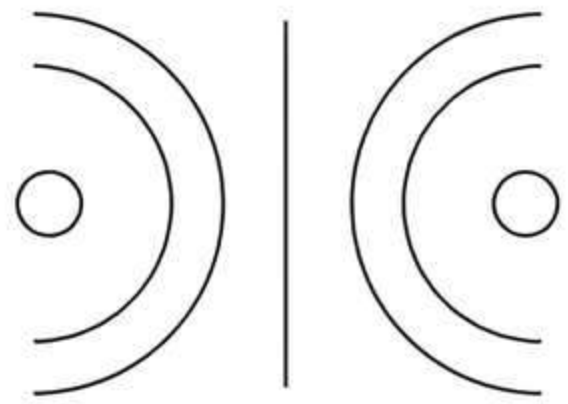
The magnetic field lines are circular near the current carrying circular loop. As we move away, the concentric circles representing magnetic field lines become bigger and at the centre, the magnetic field lines are straight.

Read the above passage carefully and give the answer of the following questions:

(i) The direction of magnetic field developed around a current carrying conductor can be easily found by the use of:

a. Fleming's left-hand rule
b. Left-hand thumb rule
c. Right-hand thumb rule
d. Fleming's right-hand rule

(ii) The diagram given below represents magnetic field caused by a current carrying conductor which is:



a. a solenoid
b. a long straight wire
c. a circular coil
d. a short straight wire

(iii) The strength of magnetic field due to a straight conductor depends on the:

a. nature of conductor
b. current passing through the wire
c. direction of current
d. All of the above

(iv) The strength of magnetic field inside a long current carrying straight solenoid is:

a. same at all points
b. minimum in the middle
c. found to increase from one end to the other
d. more at the ends than at the centre

Very Short Answer Type Questions

Q 8. What is the use of earth wire in domestic electric circuit?

Q 9. What is the direction of the magnetic field lines inside a bar magnet?

Short Answer Type-I Questions

Q 10. The given magnet is divided into three parts A, B and C.

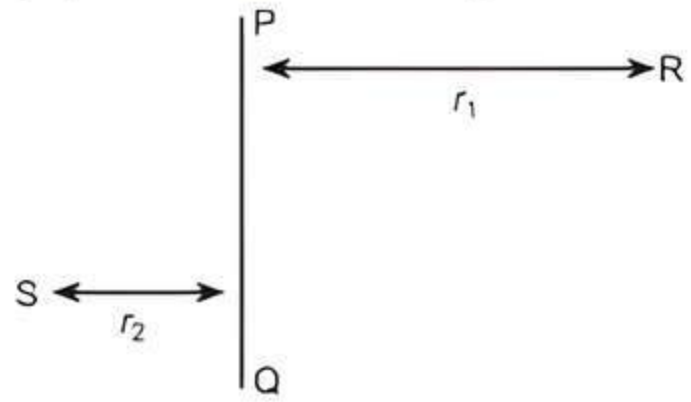
A	B	C

Name the parts where the strength of magnetic field is:

(i) maximum (ii) minimum

How will the density of magnetic field lines differ at these parts?

Q 11. *PQ* is a current carrying conductor in the plane of the paper as shown in the figure below:



(i) Find the directions of magnetic fields produced by it at points *R* and *S*?

(ii) Given $r_1 > r_2$, where will the strength of magnetic field be larger? Give reasons.

Q 12. How is the strength of magnetic field near a straight current conductor:

(i) related to the strength of current in the conductor?

(ii) is affected by changing the direction of flow of current in the conductor?

Short Answer Type-II Questions

Q 13. What is the function of an electric fuse? Name the material used for making a fuse. In a household circuit, where is fuse connected? Distinguish between overloading and short circuiting.

Q 14. What is a solenoid? Draw a diagram to show the pattern of magnetic field around a current carrying solenoid. Name the region of uniform magnetic field. *(CBSE 2023)*

Q 15. Name, state and explain with an example the rule used to determine the direction of force experienced by a current carrying conductor placed in a uniform magnetic field.

Long Answer Type Questions

Q 16. Describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors.

Q 17. What is an electromagnet? List any two uses.

(i) Draw a labelled diagram to show an electromagnet is made.

(ii) State the purpose of soft iron core used in making an electromagnet.

(iii) List two ways of increasing the strength of an electromagnet if the material of the electromagnet is fixed.